A study on stability for yield and yield contributing characters in barley (*Hordeum vulgare* L.) under Bundelkhand situation

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By

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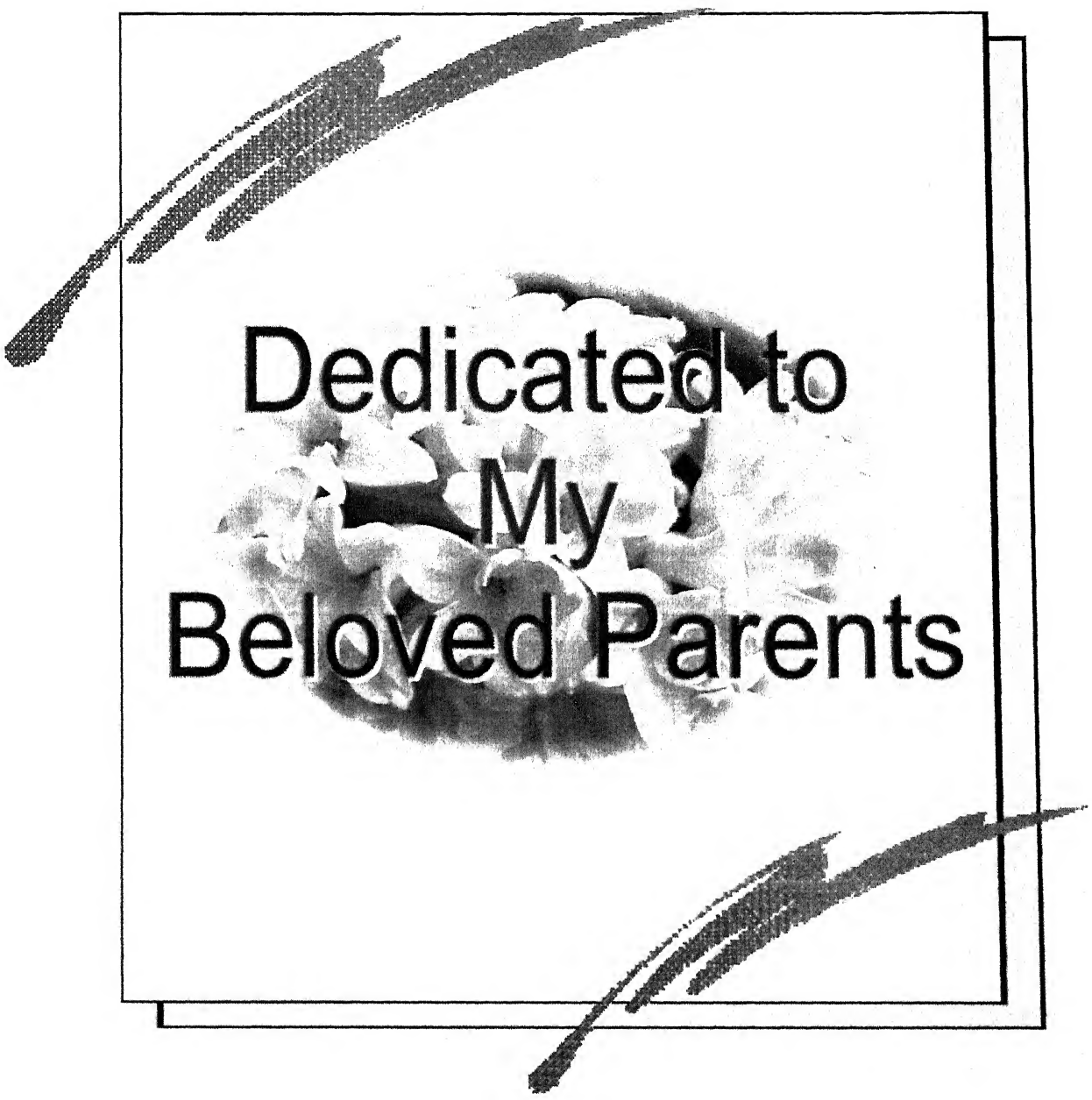
Dedicated to
My
Beloved Parents

BRAHMANAND MAHAVIDYALAYA
RATH (HAMIRPUR) U.P.

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CERTIFICATE

This is to certify that the thesis entitled **"A Study of stability for yield and yield contributing characters in barley (*Hordeum vulgare* L.) under Bundelkhand situation"** submitted to the Bundelkhand University, Jhansi for the award of the degree of ***DOCTOR OF PHILOSOPHY*** in the subject of **Genetics and Plant Breeding,** is a record of bonafide research work carried out by ***Mr. Pankaj Singh***, under my guidance and supervision and no part of the thesis has been submitted for any other degree.

The manuscript pertains to the original work of the candidate. He has worked under my guidance and supervision for more than 24 months commencing from the date of his registration as required under the Ph.D. degree ordinance of the University and has put in the required attendance for more than 200 days in the department during the period.

Place : Rath — **(S. P. Singh)**

Date : 28.11.08

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Pankaj

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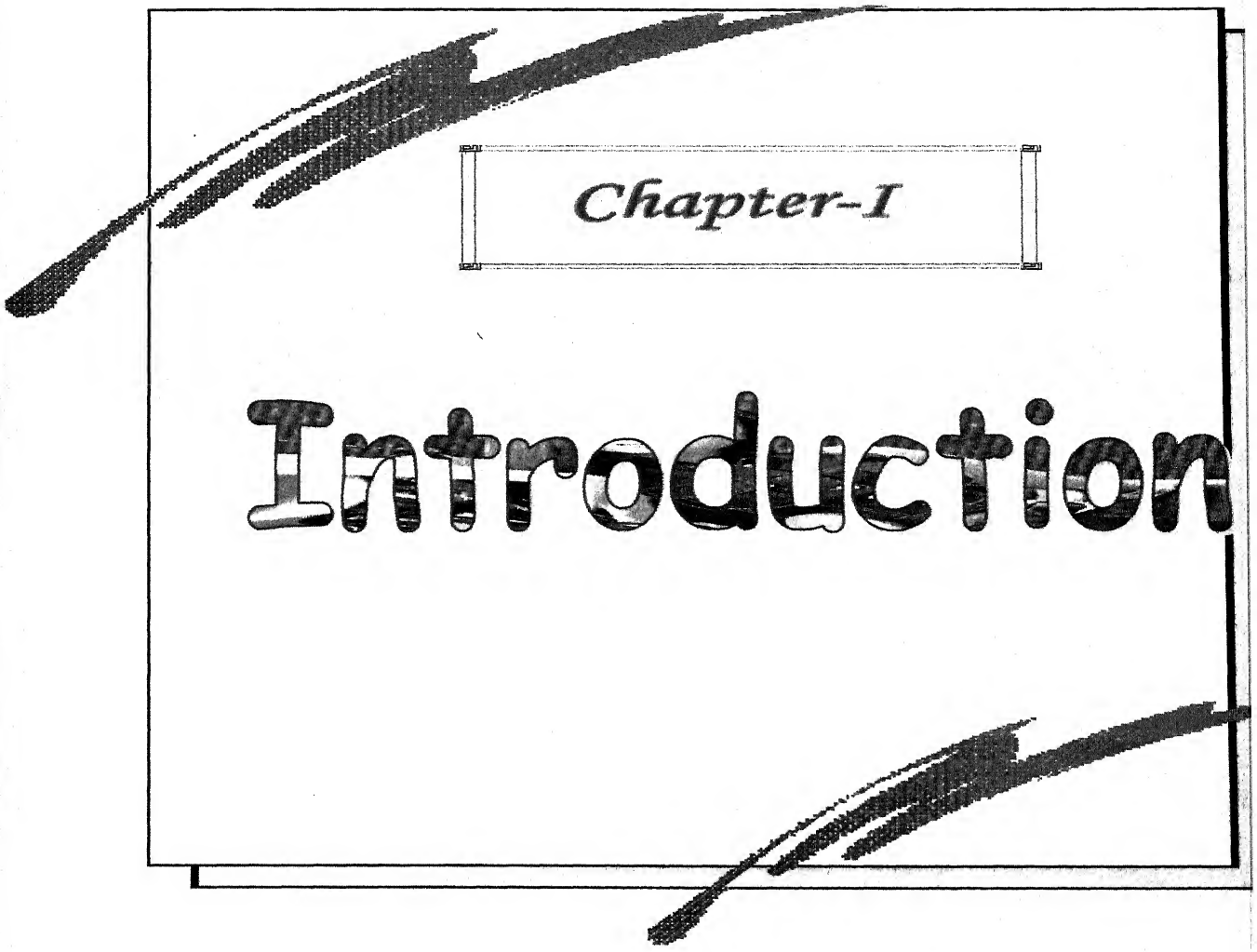

Chapter-I
Introduction

Chapter-1 INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the earliest crop to be domesticated. It is the world's fourth most important cereal after wheat, maize and rice. The barley grains are primarily used for human consumption in various preparations, as a feed for livestock, and to a limited extent for the manufacture of beverages. Barley based agro industries market bear, pearl barley, lemon barley, water and lime barley. Barley has often been used as a model crop for many research programme because of its less chromosome number, large chromosome size, easy handling and genetic markers etc. However, its yield level is low and therefore, need to be improved. During 2007, the barley production was recorded at 1550 million tonnes (MT) from an area of 826 million hectare (MH) in India (FAO, 2008).

The major barley producing countries of world are CIS (USSR), Canada, USA, Germany, France, Spain, Turkey, U.K., Denmark and Australia. India does not figures in first 15 countries of the world in terms of area and production of barley in terms of productivity, the European countries having winter type barley had with more than 5.0 tonnes/ha. The barley grain available to the industries possesses higher husk and protein content and less carbohydrate which results in poor malting qualities. The continuous decline in barley area and production during 80's and 90's triggered a shortage for good quality grains of malting.

In India major barley growing states are U.P. Rajasthan, Madhya Pradesh. Uttar Pradesh alone accounts for 44 percent of area and 45 percent of production of barley in country followed by Rajasthan, Punjab and Haryana. The states like Bihar and Madhya Pradesh with considerable

area under barley yield far below the national average of 1.73 t/ha where most of barley is under rainfed cultivation. In India more than 7.1 million hectare land is of saline/sodic nature in indo-gengatic plains and sea shores like Sunderban delta in West Bengal and parts of Gujarat.

The process of replacing thousands of local varieties or land races with a few uniform and high yielding ones has accelerated the genetic erosion of the important food and cash crop around the world. Economic superior varieties as well as agro-technical requirements related to their introduction has stimulated structural changes in agriculture practices favouring large area monocultures. This strategy has greatly improved food production but has also generated some problems related to environment and agricultural production per unit area. It has become obvious that genetic uniformity, which arose with cultivation of only few varieties with similar genetic backgrounds, makes a particular crop vulnerable to epidemic of pests, disease and elevates stress. Barley is one of the most important crop in semi arid areas of north Africa and west Asia where approximately 11 million hectares are devoted to its production.

Yield is a complex character and is the final product generated by the inherited characters that the controlled by polygenes and are markedly influenced by environmental fluctuations. Although the percentage of homozygous genotypes increases considerably with each generation, however the number of plants that are necessarily involved in the selection becomes so large that the size of population grown becomes unmanageable.

The development of an effective plant breeding programme is dependent upon the existence of genetic variability. The magnitude of variability present in the gene pool of a crop species is of ut-most

importance to a plant breeder for starting a judicious plant breeding programme. The variability is measured through parameters like heritability, genetic divergence and expected genetic gain. Heritability and genetic advance are important to provide information about correspondence between genotypic and phenotypic variance. Heritability estimates along with genetic advance are normally more helpful in predicting the grain under selection than heritability estimates alone. However, it is not necessary that a trait showing high heritability will also exhibit high genetic advance (Johnson *et al.*, 1995). The high heritability accompanied with high genetic advance indicates that most likely the heritability is due to additive gene effects and selection may be effected.

The character association among the attributes is estimated by genotypic and phenotypic correlation which is used to find out the degree and direction of relationship between two or more variables. Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects (Dewey and Lu, 1959).

The basic difference between genotype and their yield stability is the wide occurrence of genotypic environmental interaction which can be attributed to reaction of genotype to known environment such as drought and stress factors and consequently resistance breeding is of significant in improving yield stability. The adaptation is the property of genotype permitting its survival under selection whereas adaptability is the genetic ability, which results in stabilization of genotype environment interaction by means of physiological (individual) and genetical (population) reaction of organism to environments. The adaptability is thus a manifestation of genotype environment interaction (Allard and Bradshow. 1964) which is in turn is a genetic character inherited by organism through the process the

evolution (Jinks and Mathur (1955). The genotype environmental interactions have a important bearing on the plant breeding problems. An obvious and significant effect of those interactions is to reduce the correlation between phenotype and genotype with the result that the valid inferences become more complicated. This implies whether the interest is to determine the mechanism of inheritance or to evaluate new strains. Comstock and Moll (1963) have shown statistically the effect of large genotypic environment interaction in reducing the progress from selection.

Oka (1967) has classified crop adaptability into two categories (1) the general which refers to the ability of crop plants to produce a consistence high yielding under varied environmental conditions. (2) Specific which indicates the ability to react and resist to a particular condition such as cold, drought, or pests. The stability and productivity are the two consistent characters hence, it is possible to breed varieties having high yield potential, stability and high productivity. There are two concepts of stability (Static and Dynamic). In static concept the stable genotype shows variation in the performance over environments regardless of any variation of the environmental conditions. The dynamic concept permits a predictable response to environments and a stable genotype correspondence completely to the estimated level or the prediction of performance. According to the dynamic concepts, only the deviation of a genotype from this general relation is considered as a contribution to unstability because the general response of all genotypes may be interpreted as environmental effects. Several models including regression approach model of Years and Cochran (1938), stability factor of Lewis (1954), static of Plasted and Peterson (1959) and covalence of Wricke (1962) have been proposed for the estimation of (G x E) interaction. The regression approach model was later utilized by Finlay and Wilkinson

(1963) to select stable genotype in barley. Eberhart and Russell (1966) later improved upon the regression approach and added other parameters, deviation from regression (S^2di) beside regression coefficient (bi) for stability. They defined genotype with unit regression and least deviation from regression as stable genotype. Perkins and Jinks (1968) used the same two parameters for stability but at the same time modified the method of estimation of regression coefficient. They opined that instead of regression mean performance ($E_i + g_{ij}$) on the environmental index (E_i), genotype unenvironment interaction ($G \times Eg_{ij}$) should be regressed on the environmental index.

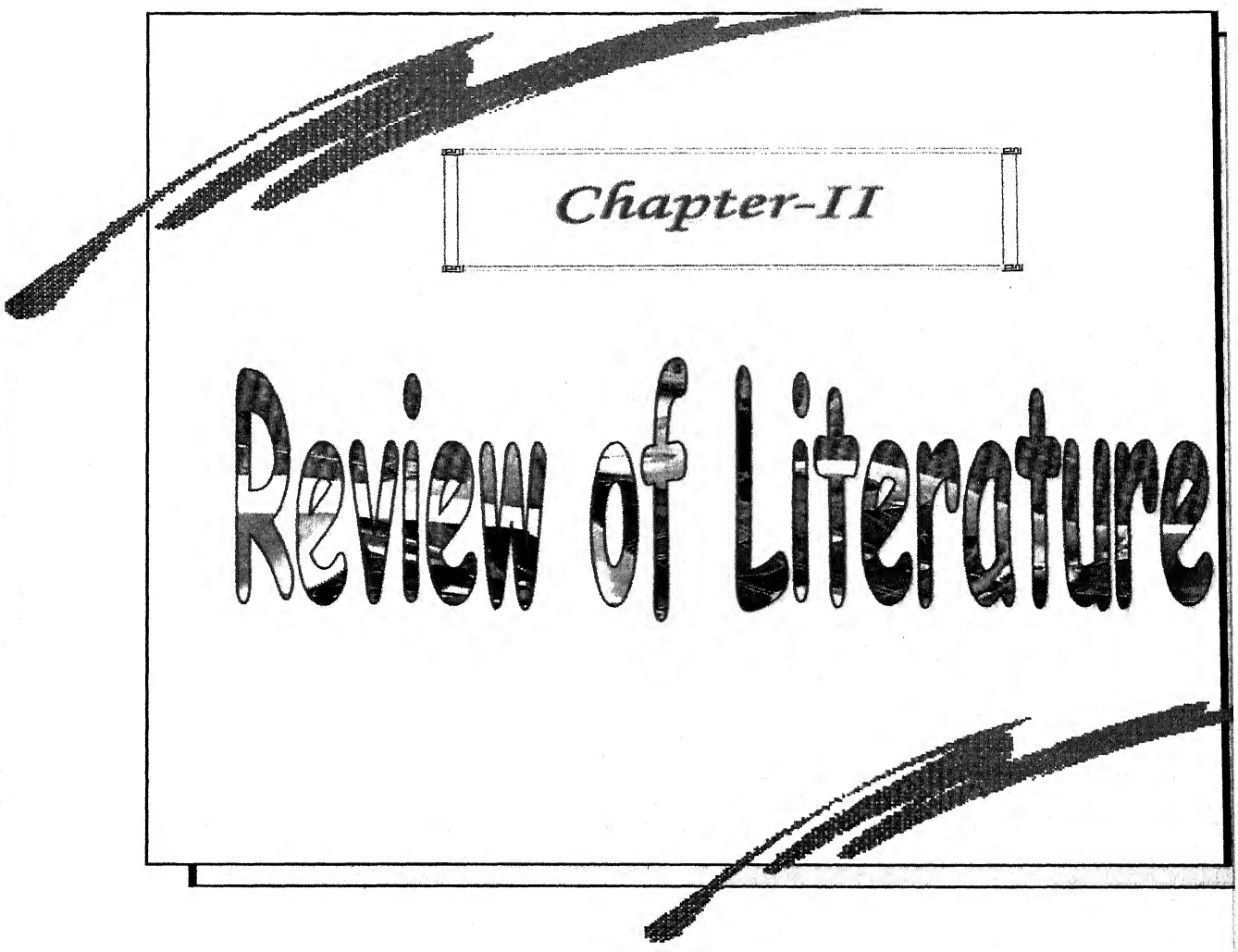
Keeping the above in view, the present investigation entitled **"A study on stability for yield and yield contributing characters in barley (*Hordeum vulgare* L.) under Bundelkhand situation"** is being undertaken with the following objectives :

(i) To find out the variability, heritability and expected genetic advance for different characters under study.

(ii) To estimate the character association between yield and its component characters through correlation and path analysis.

(iii) To find out the phenotypic stability for various characters under different environments.

(iv) To suggest a suitable breeding plan based on the present investigation.


Chapter-II
Review of Literature

Several workers have studied "**A study on stability for yield and yield contributing characters in barley (*Hordeum vulgare* L.) under Bundelkhand situation**" In this chapter, the literature pertaining to different aspects of the problems under study has been reviewed.

GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The barley is cultivated under varied agro climatic conditions. There is need to isolate, identify and characterize the varieties suitable under varied agro climatic and fertilizer conditions. This will be helpful in selection of new parent and cultivated varieties suitable under different levels of fertilizer and irrigation for breeding programme of hybridization for the crop improvement.

Yadav *et al.,* (1991) obtained information on genetic variance and heritability derived from data on 6 yield components in 8 diverse and elite barley genotypes and their F_1 and F_2 generations grown at Deoria in rabi 1979-80, cv. Ratna carried a high frequency of dominant genes for tillers per plant, ear length and grain yield per plant and cv. Jyoti for spike lets per ear and 1000 grain weight. Heritability in the F_1's and F_2's was high for tillers per plant and grain per ear.

Kaeppler *et al.,* (1991) conducted research to determine the inheritance and to examine maternal quality factor in malting barley. Heritability of alpha amylase activity was estimated by measuring activities of seed from field growths of parents and progeny. The heritability of alpha

amylase activity on an F_2 plant basis ranged from 0.37 to 0.65, while on an F_5 line basis it ranged from 0.39 to 0.74.

Yadav (1993) information on genetic variance, genotypic correlation and path analysis was derived from data on growth parameters in 25 elite varieties of barley raised under non saline and saline irrigated conditions during rabi season of 1988-90 in Haryana. Tillers/plant, spike length and 1000-grain weight showed low genetic variance as well as genotypic coefficient of variation. Heritability was lower under saline than non saline condition for all the traits except 1000-grain weight. Genetic correlation and path coefficient analysis were modified under saline stress.

Sharma and Maloo (1994) obtained information on genotypic and phenotypic variability derived from data and yield related traits in 36 F_1 hybrids and their 9 parents. Variability was high for grain yield, ear/plant and tillers/plant.

Nadziak *et al.,* (1994) tested 94 varieties of the 6 rowed type and 53 of the 2 rowed types during 1987-90. The degree of genetic variability was determined. Heritability estimates were high for ear length, hardiness, plant height and grain yield in 6 rowed types and for lodging hardiness, plant height and grain yield in 2 rowed types.

Park *et al.,* (1994) evaluated 137 accessions of wheat and barley at Research institute of Suwon during 1988-89. The heritability estimates for starch content was 30 per cent.

Lu *et al.,* (1995) conducted trials with 5 cultivars of two - rowed barley. Heritability of various characteristics with seed yield/plant was low showing that the choice of a single character in selection is inefficient. The number of ears/plant was the most effective character for selection. The

most effective combination of characters for high yielding selection was number of ears/plant, number of seeds per ear and seed yield.

Kudla *et al.,* (1995) studied of F_2 hybrids from reciprocal crosses between the induced mutant M-96, with many ears per plant and the strain B-81, with many grains per ear, non additive gene action played the predominant role in the inheritance of grain yield per plant and plant height. Additive genes were more important in the inheritance of grain number per ear, ear number per plant and 1000 grain weight. Heritability estimates were highest for plant height and lowest for number of ears per plant.

Sajeda Begum *et al.,* (1997) reported that the grain yield had the highest phenotypic and genotypic coefficient of variation, followed by number of fertile tillers. All the traits studied possessed high heritability values, the highest being for grain yield. Genetic advance was high for grain yield followed by number of fertile tillers and grain size.

El-Hennawy (1997) conducted two field experiments to estimate the genetic coefficient of variation, heritability and genetic advance in 6 yield components measured from 20 barley cultivars (8 Local and 12 German cultivars). Path analysis was used to assess the relative importance of plant characters contributing to yield. The results indicated that the highest genetic coefficient of variation was obtained for grains/spike and grain yield per plant while lowest values were recorded for plant height and 100-kernel weight. The heritability estimates ranged from 29.03 percent for harvest index to 71.30 percent for per spike. Expected genetic advance with selection of the highest 5 percent, expressed as a percentage of the mean, ranged from 11.62 percent for plant height to 58.31 percent for grains per spike.

Martinez *et al.*, (1998) reported the broad sense heritability for heading data ranged from 42 to 86 percent values obtained for grain yield 12 to 27 percent were more consistent among broad sense than narrow sense estimates genetic advance estimates were low due to lack of additive variance.

Leebu Babu *et al.*, (1998) studied on genetic variability among 56 malting barley genotypes (comprising 23-2-rowed barley) for 16 quality and yield components. Seeds/spike, spikes/m^2, tillers/m^2, 1000-grain weight and seed yield/plot exhibited high heritability estimates coupled with high estimates of genetic advance. This implied the presence of adequate variability among genotypes for further improvement based on additive gene action. Days to 50 percent flowering and days to maturity had low heritability.

Vimal and Vishwakarma (1998) observed that broad sense heritability ranged from 3.9 (days to maturity) to 967.8 percent (grain yield/plant) high heritability coupled with high genetic advance was noted for tillers/plant, spike length, spikelets/spike and grain yield/plant.

Sinha *et al.*, (1999) studied on two crosses of barley namely BR 31x BM and K 69 x Ratna, in Bihar, India. In BR 31 x BM 4, high estimates of various heritabilites and intermediate genetic advance were recorded for days to heading, heritability were high but genetic advance as percolage of mean was low for grain yield per plant in K 69 x Ratana, medium to high estimates of various heritabilites were associated with high estimates of genetic advance for grain yield per plant. The heritabilities for tillers per plant, spike length, grains per spike and 1000 grain weight were low to intermediate.

Ram Kishore *et al.*, (2000) observed that high estimates of phenotypic and genetic coefficient of variability were obtained for plant height, flag leaf length, number of grains/ear and grain yield/plant. High estimates of heritability coupled with high genetic advance were recorded for plant height, number of tillers/plant, flag leaf length and ear length.

Pilania, (2005) information on genetic variance, genotypic correlation and path analysis was derived from data on growth parameters in 30 varieties of barley. Tillers/plant, spike length and 1000-grain weight showed low genetic variance as well as genotypic coefficient of variation. Heritability was lower under saline than non saline condition for all the traits except 1000-grain weight. Genetic correlation and path coefficient analysis were modified under saline stress.

Dhama (2007) estimated the genetic coefficient of variation, heritability and genetic advance in 7 yield components measured from 25 barley cultivars. Path analysis was used to assess the relative importance of plant characters contributing to yield. The results indicated that the highest genetic coefficient of variation was obtained for grains per spike and grain yield per plant while lowest values were recorded for plant height and 100-seed weight. The heritability estimates ranged from 30.55 percent for harvest index to 69.66 percent for per spike. Expected genetic advance with selection of the highest 6 percent, expressed as a percentage of the mean, ranged from 10.89 percent for plant height to 60.24 percent for grains/spike.

CORRELATION COEFFICIENTS

The results of correlation analysis were presented by the Khodzhakulu (1980) for yield and 7 related characters in two varieties. Yield was closely related with number of ear~~s-bearing~~ tillers/m^2, 1000- grain weight and number of grains/ear. Correlation analysis ~~result are~~ presented between yield component~~s the coefficient of correlation~~ varied according to environmental conditions and agronomic practices but were successfully used as the basis for selecting for high yield grain set and tiller number.

Merskow *et al.*, (1985) ~~suggested that~~ from the reported that analysis of data on yield and 7 related characters in 6 F_2 hybrids, grain number/ear was correlated with grain weight/ear (r=0.65) and ear length (r=0.48) while plant height was correlated with ear length (r=0.54) and number of fertile tillers (r=0.32). It is thought that grain number/ear is a promising ~~indirect~~ character for use in selecting for a grain yield in F_2 population.

Singh (1987) studied ~~that~~ the nature of direct and indirect effects of the major yield characters in hull less barley by using path analysis. In general genotypic correlation was higher than the phenotypic correlation under all the three irrigated, rainfed and late sown cropping conditions. Grain yield exhibited positive correlation with number of ears per plant and 1000-grain weight, negative association was observed with plant height and ear length.

Singh and Singh (1990) reported that ~~studied~~ grain yield was positively correlated with length of flag leaf, number of internodes per plant and number of ears per plant under rainfed and irrigated conditions and with stem length under rainfed conditions only.

Lin and Yu (1990) analyzed beta amylase activity and malt diastatic activity (ability to produce maltose from starch using its own diastase (alpha glucosidase) in mature seeds of 10 two rowed barley cultivars and 10 F_2 hybrids which indicated that beta amylase activity was significantly correlated with malt diastatic activity (r=0.991). Alpha amylase activity was correlated with malt diastatic activity (r=0.50). Malt diastatic activity may be predicted by testing beta amylase activity.

Hadjichirstodoulou-A (1991) conducted a field experiment in 1988-89 with upto 65 barley genotypes were grown at 20 different Mediterranean sites with annual precipitation of 236-500 mm. He concluded that optimum plant height under dry land conditions is about 100 cm, consistently high yielding cultivars were among the most stable in height. The plant height was positively correlated with grain yield, straw/ yield and total plant dry matter in most experiments.

Dolicki (1992) conducted ~~a plot~~ experiment at various sites in the Beskide foothills over 5 years. Agronomic traits were investigated in 86-2 rowed winter cultivars of barley, ~~generally~~ tillering, ear length, 1000-grain weight were better in two rowed barley cultivars. For two rowed cultivars and strains, the weight of grains/ear was correlated with seed number/ear (r=0.549) and 0.508 while for multi rowed cultivars the weight of grains/ear was correlated with seed number/ear (r=0.765) and 1000- grain weight (r=0.465). Relation among other traits were not significant. The best over wintering multi rowed cultivars show ~~lower~~ seed weight/ear and seed weight/plot as well as lodging tendency. ~~Local high yielding cultivars mean is recommended for maintain conditions because of its frost hardiness.~~

Mandal and Dana (1993) reported that seed yield exhibited positive and highly significant genotypic association with flag leaf area, number of

grains/ear, length and width of grain and 1000-grain weight. Flag leaf area showed positive correlation with all the traits measured.

Yadav (1993) reported that under saline condition, grain yield was positively correlated with tillers per plant and 1000-grain weight. Plant height had positive correlation with tillers per plant and 1000-grain weight.

Theoulakis *et al.*, (1994) estimated the correlation coefficient in F_3 and F_4 between grain yield and harvest index and between grain yield and biomass were high and very high respectively. From the F_3 to the F_4, the correlation significant for harvest index in all pupulations, while between harvest index and grain yield were significant in only one population.

Savin *et al.*, (1996) indicated that decreases in grain dry matter were due to reductions in number rather than size of starch granule. It was concluded that high temperature reduced the amount of maltable grain by reducing grain size and increasing the screening percentage and also reduced malt extract by 3-7 percent which represents a large decrease for the malting industry.

El-Hennawy (1997) in interrelationship study showed positive and significant phenotypic and genotypic correlations between grain yield per plant and each of grains/spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 100-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding.

Irfan-ul-Haq (1997) grown twelve (12) husked barley at Faisalabd for correlation and path analysis for grain yield and its components and Positive association of grain yield with 1000 grain weight and number of

spikelets per spike. However, grain yield was negatively asociated with days to heading.

Singh *et al.,* (1998) evaluated eight elite lines and their 28 F_1 hybrids. The data obtained were used to estimate correlation coefficient. Grain yield/plant was correlated significantly with spikelets/ear, straw strength, tillers/plant and 1000-grain weight. Associations between tillers/plant, spikelets/ear and 1000-grain weight were also positive and significant with grain yield/plant.

Verma *et al.,* (1998) raised eighteen indigenous genotypes of barley cultivars to study correlation and path coefficient among 11 characters. grain yield showed higher positive and significant association with number of ears/plant, 1000- grain weight. However, positive and significant correlations were also observed for grains/ear, grain weight/ear, 1000-grain weight.

Subhash *et al.,* (1998) conducted a field trial at Jobner. Rajasthan in rabi (winter) 1994-95 barley cv RD 2052 was given 30, 60 or 90 kg N/ha, 0, 15 or 30 kg zinc/ha and 0 or 0.125 percent mixtalol spray. yield attributes increased with rate of N application. Application of 60 kg N/ha significantly increased the yield attributed over 30 Kg N but was at par with 90 Kg N. Grain yield had a positive and significant correlation with effective tillers, ear length, number of grain per ear and test weight.

Ram Kishor *et al.,* (2000) reported that grain yield/plant exhibited significant and positive association with plant height, number of tillers per plant, number of grains per ear and 1000-grain weight. The 1000-grain weight was also positively and associated with plant height and number of tillers per plant. Significantly

Bhattacharya (2005) studied that the nature of direct and indirect effects of the major yield characters in barley by using path analysis. In general genotypic correlation was higher than the phenotypic correlation under all the three irrigated, rainfed and late sown cropping conditions. Grain yield exhibited positive correlation with number of ears per plant and 1000-grain weight, negative association was observed with plant height and ear length.

Singh and Khare (2008) in interrelationship study showed positive and significant phenotypic and genotypic correlations between grain yield per plant and each of grains/spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 100-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding

PATH COEFFICIENT ANALYSIS

Singh (1987) reported that days to 75 percent heading had maximum direct effect on yield at the genotypic level and number of ears/plant at the phenotypic level in 11 varieties under irrigated conditions. In rainfed conditions ear length, number of ear/plant, days to 75 percent maturity, number of spikelet/spike exerted a direct effect on yield at the genotypic level while number of ear/plant and number of grains/spike had the greatest effect at the phenotypic level. Under late sowing conditions, the grain yield was directly influenced by the number of grains/spike, plant height, days to 75 percent maturity and 1000-grain weight at the genotypic level and all the characters except number of spikelets/spike at the phenotypic level.

Singh and Singh (1990) studied yield grain traits of barley (*Hordeum vulgare*) in the parental, F_1 and F_2 generations of an 11-parent

diallel crossing grown during rabi 1986-87 in Varanasi, India. Path coefficient analysis indicated high positive direct effects on grain yield for number of internodes and ears per plant under both conditions. Highly positive indirect effects of grain yield were given by number of internodes and ears per plant under both conditions and by stem length under rainfed conditions only.

Garcia *et al.,* (1991) reported that grain yield of barley is influenced by several yield components and also by the duration of the vegetative and grain filling periods. Path coefficient analysis based on an autogenetic approach were conducted to study the relationship among grain yield, yield components and duration of the vegetative and grain filling periods in 9 genotypes (including seven near isogenic lines) of spring barley varying in heading dates and several morphological traits grown in two environments ~~in the province of Granada in southern Spain~~. Grain yield variation between environments and from year to year depended mainly on two yield components viz., number of spikes/m^2 and number of grains/spike. Duration of the vegetative period had a positive influence on grains/spike and a negative influence on length of the grain filling period.

Ganesheva *et al.* (1992) studied ~~of~~ the plant height and 8 yield traits in F_1 progeny from the crosses 234 x Alfa and Ruen x Alfa. Grain per plant and 1000 grain weight had the greatest direct effect on ~~numbers grain weight~~ grain yield per ~~plant irrespective of whether the~~ both at phenotypic or genotypic ~~correlations formed the basis of the path coefficient~~ levels. These two traits are recommended as reliable criteria for use in selection for yield.

Mandal and Dana (1993) reported that path coefficient analysis indicated that the number of grains/ear directly influenced the grain yield followed by 1000-grain weight and width of grain.

Yadav (1993) conducted a experiment during the winter season of 1988-1989, 1989-1990 to study genetic parameters in 25 elite varieties of barley under saline and non-saline conditions. Path coefficient analysis showed the positive and significant correlation of tillers per plant with grain yield was due to its high positive direct effect as well as positive indirect effect via plant height. The high negative effect of spike length was mainly due to direct effect of this component and indirect effect via tillers per plant.

Kudla-MM (1995) obtained information from a study of F_2 hybrids from reciprocal crosses. 1000 grain weight had the greatest effect on yield in parents, while ear number per plant had the greatest effect on yield in the hybrids.

Maled-BG and Hanchinal (1997) recorded the data on 10 Yield components in 26 genotypes of barley grown during rabi 1992 was subjected to path analysis. The spikes per m^2 excited the maximum effect on grain yield.

Naik *et al.,* (1998) evaluated twelve genotypes of 6-rowed barley at Dharwad in *rabi* season and yield was positively correlated with productive tillers/m^2. Path coefficient analysis indicated that direct selection for productive tillers/ml, grains/spike and against plant height can improve yield.

Verma *et al.,* (1998) raised eighteen (18) indigenous genotypes of barley to study correlation and path coefficient among 11 characters. The path coefficient analysis revealed that ears per plant, grains per ear and 1000 grains weight were direct contributors to grain Yield, whereas length of main ear, weight of grains per ear were indirect contributors via three characters.

Fathi and Rezaeimoghddam (2000) observed significant differences between genotypes for grain yield, above ground biomass and number of tillers. Among yield components, spike number/m/ and number of grains per spike had the largest direct effect on grain yield (0236) However, its negative indirect effect reduced the correlation coefficient of spike number/m2 With grain Yield (-0 104). Number of seeds/spike had the highest effect through spike number/m^2 ~~(0 118)~~ and 1000-graln weight decreased grain yield (-0.055). The number of grains per spikelet had less indirect effect on grain yield through weight in spike and spike number/m^2 and also had no effect through spike length on grain Yield. However, with respect to residual effects (0.529) half of the number/m^2 and grain number in spike had the largest direct effects on grain yield and that these characters could be used. In selection of high yielding barley cultivars

Pilania (2005) studied on path coefficient analysis in barley and indicated high positive direct effects on grain yield for number of internodes and ears per plant ~~under both conditions~~. Highly positive indirect effects of grain yield were given by number of internodes and ears per plant ~~under both conditions~~ and by stem length.

Singh and Khare (2008) showed positive and significant phenotypic and genotypic correlations between grain yield per plant and ~~each~~ of grains per spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 100-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding

STABILITY AND ITS CONCEPT

Genetic diversity plays an important role in preserving the stability of the ecosystems in the biosphere. The term phenotypic stability, yield stability, adaptability and adaptation are quite often used in different senses.

Lewis (1954) defined phenotypic stability as the ability of an individual or population to produce as certain narrow range of phenotypes in different environments.

Allard and Bradshaw (1964) stated that stability does not imply general constancy of phenotype in varying environments. In fact its may, depend on holding some aspects of morphology and physiology in steady state. Thus, the required varieties will show low genotype environment for agriculturally important characters, particularly yield. A variety, which can adjust its genotype or phenotypic state in response to transient fluctuations in environment in such a way that it give high and stable economic return, can be termed 'well buffered.

Broadshaw (1965) found that the expression of an individual genotype can be modified by the environment. The amount by which it can be modified, can be termed as 'plasticity' and there can be considerable interrelationship among plasticities of different characters.

Lin *et al.,* (1986) amplified that concept of stability is defined in many ways depending on how the scientist wishes to look at the problem. In fact, depending on goal and on the characters under consideration. Two different concepts of stability exists i.e. static and dynamic concept of stability. In case of static concept, a stable genotype possesses an unchanged performance regardless of any variation of the environmental

conditions. This stable genotype shows no deviation from the expected character level that means its variance among environments is zero.

The dynamic concept permits a predictable response to environments and a stable genotype has no deviation from this response to environments meaning thereby that for each environments the performance of a stable genotype corresponds completely to the estimated level, termed the dynamic concept as the agronomic concept of stability and static concept as biological concept of stability. Static concept of stability is useful for traits whose levels have to be maintained at all cost. However, this stability is associated with a relatively poor yield level.

STABILITY PARAMETERS

The inconsistency in the performance of genotypes over a range of environments has been the concern of the breeders since long back. Various stability parameters/statistics have been developed to measure the phenotypic stability. The presently used line (g) stability parameters have been reviewed by Plaisted and Peterson (1959), Wricke (1962), Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968); and Lin et al. (1986).

The parametric approach to stability has the advantage of computational simplicity. For the use of proper statistics, the concept of stability and kind of environments, included in the experiment are to be clearly understood. In general, the following statistics are useful if the scientist is concerned about (i) stability over an entire range of environments, then group A (SL_i and Cv_i) is useful, (ii) Comparing relative stability among the group of cultivars and if regression model fits the data, group C (Finlay and Wilkinson. Perkins and Jinks) is the best. (iii) When the

data do not fit or if the residual MS from the regression are heterogeneous, group B (Wi or CJ^2i) is the best and (iv) besides above described season Group 0 (Eberhart and Russell. Perkins and Jinks) is the best.

VARIANCE G x E INTERACTION

Plaisted and Peterson (1959) described a procedure to characterize the stability of the performance of several varieties tested at a number of locations within one year. A combined analysis of variance overall locations was computed for every pair of genotypes to estimate the interaction variance of variety x location for each pair of variety [g(g-1)/2 pairs]. The mean of variance of V x L interaction obtained for each variety/genotypes was used for comparison. The variety with smallest mean value of interaction variance was considered as the most stable variety.

Ecovalence (Ecological valence)

Ecovalence (Wi) is the contribution of each genotype to the G x E interaction. Wrickle (1962) proposed ecovalence (Wi) as a stability measure using the G x E interaction effects for each genotype. Squared and summed across all environments. The lower ecovalence of a variety, the smaller are its fluctuations from the experimental mean under different environments and thus a smaller contribution to the G x E interaction. Accordingly, a variety with the least ecovalence (Wi=0) is considered as more stable.

Yates and Cochran (1938) proposed regression analysis to interpret the degree of association between varietal differences and general fertility by calculating the response of yield of ~~separate~~ individual varieties on the mean yield of all the varieties.

Finlay and Wilkinson (1963) used the simple linear regression to describe various type of variety adaptability to a range of environments. which can also be used as a quantitative measure of phenotypic stability. The observed mean values of each variety are regressed on environmental indexes defined as the difference between the marginal means of environments and the over all mean. The regression coefficient (bi) for each genotype is taken as its stability parameter. Absolute phenotypic stability is expressed by bi=0. This method seems to be quite useful as the regression coefficient represents a greater part of yield variation caused by the environmental fluctuation.

Perkins and Jinks (1968) proposed a biometrical model unlike purely statistical models (Finlay and Wilkinson model and Eberhart and Russell model) which specifies the contribution of genetic, environmental and G x E interaction and extended the analysis to cover many inbred lines and crosses among them. Followed by regression analysis similar to that of Finlay and Wilkinson model except that the observed values are adjusted for location effects before the regression analysis. The G x E effects on environments indices were regressed so that G x E variance to partitioned into a component due to pooled deviation from regression. If either or both have the two components are significantly greater than the experimental error G x E interaction is present If the heterogeneity component alone is significant. All the G x E interaction for an individual genotype can be predicted from the linear regression on environmental values If the remainder component alone is significant there is no simple or linear relationship between G x E interaction and environmental values and hence on predictions can be made by this approach.

Eberhart and Russell (1966) proposed a more elaborate method based on regression technique for measuring the stability of single and three way cross of maize They calculated an environmental index (I)) for each environment as the mean of all varieties at one environment minus the grand mean of all environment and the regression of observed mean values of genotypes are estimated on environmental indices. Further, They introduced deviation parameter (S^2di) as the residual mean square (MS) of deviation from the regression. The regression (bi) of the variety mean on environmental index and deviation parameter are used as the measures of stability for each genotype. According to their definition, a stable variety is the one having b=1 and $S^2di=0$. However, a desirable variety is the one which has a high mean (X), unit regression (bi= 1) and deviation from regression as small as possible ($S^2di=0$).

Breese (1996) and Paroda and Hayes (1971) advocated the use of regression coefficient as a measure of sensitivity in different crops.

Hadjichristodoulou (1974) found stability of 1000-grain weight and its effect on correlation with 8 other traits were studied in 50 varieties (18 two-rowed and 32 six-rowed barley) at 10 sites with two sowing dates. 30 and 120 kg/ha at each site additional material was used to study genotypic correlation among traits significance differences In stability of 1000-grain weight were found among 2-rowed varieties were on average more stable than 6-rowed varieties. The 1000-grain weight was among most stable and grain yield the most variable of trait.

Verma and Ram (1990) found that Hulled BHS-25 and Hull less HBS-23 and BHH proved stable for grain yield. Hulled BHO-113 and HBO-316 were high yielding but unstable and suitable only for better environment. The stability of regression analysis for studying the

phenotypic stability of grain yield was investigated using a collection of 220 Nordic barley lines. Linear regression explained 26-52 per cent of the genotype x environment interactions in different grouping of the material. The regression coefficient (bi) measures and yield response of the i^{th} genotype to improve environmental conditions, yield had the highest repeatability with correlations between years ranging from 0.57 to 0.85.

Noaman *et al.,* (1992) conducted field trials in 1988-90 in the north western region and north Sinai, 27 lines and cultivars of barley were grown at five environments varying in soil type, soil fertility, precipitation and temperature. Five barley genotypes exhibited both high yield and high stability. Rank correlation showed that environment has influenced some genotypes, while some other genotypes were relatively consistent in ranking at different environments.

Nissila *et al.,* (1992) used four parameters in analysis of yield stability, bi, S^2di, r^2i and environmental variance (S^2i), 6 genotypes of barley and analyzed in each year 6 trials from different parts of fin land from the years 1987-89 The multi year result were considered as reliable data with which to estimate yield stability. The variation between years was highly significant, there was no interaction between genotypes and years on the basis of this study, the genotype x location interaction seems to be more important factor than genotype x year interaction in barley breeding for finish conditions However, a series of 3 years may not be sufficient for indicating genotype x year interactions.

May *et al.,* (1993) studied the response of barley grain yield to Canadian prairie environments was studied to evaluate genotype x environments interactions with respect to barely genotype selection. Information from a test site and 11 entries over two 3 year span was used.

Genotype x location x year interaction from analysis of variance were significant for grain yield in both data sets.

Oliveira *et al.,* (1994) evaluated 14 genetically diverse barley genotypes at St. Paul in 1990-92 and at Crookston in 1990 and 1991, and four populations (resulting from crosses of an 6 row Minnesota line, M 66 with each of 4 European 2 row genotypes, Cheir, Remina. Caebcco 8858 and SV 83637). Data were obtained using digital image analysis of starch granules. Significant differences were found among the 14 barley genotypes of five six granule traits. Environment had a significant effect on four granule traits, but genotype x environment interaction (G x E) were not significant. Heritabilities were encouraging on a genotype mean basis in the 14 genotype study.

Fekadu-Fufa (1995) evaluated 15 barley genotypes in five environments in North-Western Ethiopia to determine their performance and stability. The combined analysis of variance showed highly significant (P less than 0.01) genotype, environment and genotype x environment effect on grain yield. The regression coefficient for the 15 genotypes ranged from 0.884 to 1.348 and were not significantly different from 1.00. Genotype PG 3510 (I), PG 3515 (I), and PG 319 (I) with regression coefficient close to 100, minimum deviation from regression and which had mean yield above the grand mean were facely stable. In performance across the environments, Kulumasa 1/88 and Kulumasa 7/88 in that order appeared more productive were growing conditions are favourable.

Nurminieml *et al.,* (1996) studied the suitability of regression analysis for phenotypic stability of grain yield using a collection of 220 Nordic barley lines. Linear regression explained 26-52 percent of genotype x environment (G x E) interactions in different grouping of the material yield

had the highest repeatability, with correlations between years ranging from 0.57 to 0.85, genotype react differently to the yearly climatic variations. Six rowed barleys had higher responsiveness. But lower mean yield, than two rowed barely.

Das *et al.,* (1996) reported the significant differences among varieties for all the characters under study, revealing the presence of sufficient variability in the genetic materials. Mean square due to environment, genotype x environment interaction showed differential response of genotypes with respect to environments. Both linear and non-linear components of G x E interactions were significant for productive tillers/m2 and grains per panicle.

Kara, (1997) evaluated 12 bread wheat genotypes over five environments to evaluate different stability parameters and rank correlations among them. From the information on mean yield and comparative stability parameters. Kate-A-1 was judged as the most stable genotypes. The mean yield was significantly correlated with coefficient of determination (r^2i). The linear regression (bi) statistic showed significant positive correlation with genotypic variance (S^2j) and coefficient variability (Cvi). The covalence stability index (W^2i) and stability variance were perfectly correlated (r=1.00).

Przulj *et al.,* (1997) analyzed in 10 spring malting barley genotypes grown at Novi Sad in 1986-88. The importance of genotype x year interaction for malt fine extract and grain protein contents was determined by means of the regression coefficient and deviation from regression as parameters of stability. The malt fine extract content depend mainly on the year. A Significant positive correlation was found between yield and the coefficient of regression for malt fine extract content.

Salem *et al.,* (1998) indicated that the genotype x environment interaction components accounted for the most part of the total variation for grain yield and its components i.e spikes/m^2, grain/spike and 1000grain weight. Regression coefficient (bi) values varied among the genotypes.

Thakur *et al.,* (1999) conducted trial on 75 cultivars of barley of wide origin under rain fed conditions over 3 years for stability analysis. DL-78 and DL-226 were stable for high yields and are suitable for commercial cultivation. Ratan having a high production potential may be suitable for specific favourable environments.

Farshadfar (1999) reported that the relative contribution of seeds/ spike in the genotype-environment interactions was higher than those of spikes/plant and seed weight. It was also observed that the sensitivity of seeds/spike to the environmental fluctuations was less than that of the other two components and hence plays a more important role in the phenotypic stability of wheat.

Upreti (1999) reported the presence of G x E interaction for all the characters except tillers per meter. The linear component of G x E interactions was significant for days to head, days to maturity, spike length, grains per spike and 1000-grain weight. Non-linear component was significant for most of the characters except days to maturity, spike length and spikelets per spike.

Mishra *et al.,* (2000) reported that eight promising wheat genotypes (GW-190, 01-803-3, Raj-1555, WH-142, DL-DL-788-2 and WH-533) were sown in Madhya Pradesh, India during 1996-97 and 1997-98 on 3 different dates (normal. 22 November. late. 2 December, and very late. 12 December) Results showed that DL-788-2 and GW-190 had higher

adaptability and stability, and may be recommended for normal and late sowing conditions, The cultivar WH-147 was responsive to rich environments and may be recommended for cultivation based on normal sowing dates. DL-803-3 and Raj-1555 showed stability and sustainability under poor environmental conditions and may be recommended for cultivation under late sowing conditions.

Sial *et al.,* (2000) reported that the stability for yield performance and genotype x environment (G x E) interaction was studied in 12 wheat (*Triticum aestivum*) genotypes grown at 13 contrasting sites. The combined analysis of variance over all environments revealed highly significant (P 60.01) difference for genotypes, environments and G x E interaction. An adaptation analysis was applied to estimate the (bi) and deviation from regression coefficients (S^2d) for each genotype.

Costa *et al.,* (2001) obtained information from barley cultivars across 17 environments (location, years) ~~in Maryland, USA from 1994 to 1997 and~~ to examine the effect of locations and years of testing on grain yield performance ~~in this region.~~ Significant differences were observed among barley cultivars and experimental lines for grain yield, plant height and heading ~~data~~ Grain yield was positively correlated with plant height and negatively with heading ~~data~~. Genotype x environment interactions measured through regression analysis were significant for grain yield, heading ~~data~~ and plant height. Most barley genotypes tested (90%) had regression slope for grain Yield that did not differ from 1.0.

Pilania and Dhaka (2004) stated that stability does not imply general constancy of phenotype in varying environments. In fact its may, depend on holding some aspects of morphology and physiology in steady state. Thus, the required varieties will show low genotype environment for

agriculturally important characters, particularly yield. A variety, which can adjust its genotype or phenotypic state in response to transient fluctuations in environment in such a way that it give high and stable economic return, can be termed 'well buffered.

Dhama (2007) stated the significant differences among varieties for all the characters under study revealing the presence of sufficient variability in the genetic materials. Mean square due to environment + genotype x environment interaction showed differential response of genotypes with respect to environments. Both linear and non-linear components of G x E interactions were significant for productive tillers/m^2 and grains per panicle.

Verma (2008) reported the importance of genotype x location interaction fro malt fine extract and grain protein contents was determined by means of the regression coefficient and deviation from regression as parameters of stability. The malt fine extract content depends mainly on the location. A Significant positive correlation was found between yield and the coefficient of regression for malt fine extract content.

Chapter-III

Materials and Methods

The present investigation entitled **"A study on stability for yield and yield contributing characters in barley (*Hordeum vulgare* L.) under Bundelkhand situation"** was carried out during the year 2006-07 and conducted at two different locations viz., experimental farm of Brahmanand Mahavidyalaya, Rath, Hamirpur and Attarra Degree College, Attarra, Banda (U.P.). The details of the materials and methods are described below :

3.1 MATERIALS

Forty genotypes of barley (*Hordeum vulgare* L.) were used for studying the variability, heritability, genetic advance, character association and phenotypic stability. The list of the genotypes is presented in Annexure-I.

3.2 EXPERIMENTAL DETAILS

The barley (*Hordeum vulgare* L.) germplasm lines were grown in a Randomized Block Design with three replications at two locations one at experimental farm of Brahmanand Mahavidyalaya,Rath, Hamirpur and another at Attarra Degree College, Attarra, Banda (U.P.) during 2006-07under two fertility levels and two sowing date conditions. Two meter row length and row to row spacing was kept at 25cm. The experimental materials consisted of 40 genotypes of barley (*Hordeum vulgare* L.) collected from C.S. Azad University of Agriculture and Technology, Kanpur .

Annexure-I : List of genotypes

S.No.	Genotypes	S.No.	Genotypes	S.No.	Genotypes	S.No.	Genotypes
1	RD-2684	11	BH-851	21	K-1149	31	K-791
2	K-273	12	K-370	22	K-551	32	K-794
3	Manjula	13	K-729	23	K-790	33	Amber
4	K-678	14	BEU-73	24	Lakhan	34	K-675
5	Vijaya	15	K-341	25	K-804	35	K-141
6	Jagrati	16	K-603	26	RD-2035	36	K-508
7	Jyoti	17	K-683	27	K-318	37	K-745
8	PL—781	18	K-792	28	K-1155	38	K-713
9	K-169	19	K-784	29	K-789	39	DL-65
10	K-252	20	K-409	30	K-633	40	DL-88

Details of both environments in both locations :

Environments	Sowing date	Fertilizer dose
Brahmanand Mahavidyalaya, Rath		
I	Normal	Normal
II	Normal	Low
III	Late	Normal
IV	Late	Low
Attarra Degree College, Attara, Banda		
I	Normal	Normal
II	Normal	Low
III	Late	Normal
IV	Late	Low

3.3 OBSERVATION RECORDED

Observations were recorded on 3 randomly selected competitive plants from each accessions.

3.3.1 Days to 50 % flowering

Total number of days from date of sowing to emergence of flowers in 50 % plants were recorded.

3.3.2 Days to maturity

Number of days from date of sowing to 75 per cent maturity were recorded.

3.3.3 Plant height (cm)

Height of the plants was measured in centimeter from base of soil to top of the plant prior to harvesting of the crop.

3.3.4 Number of tillers per plant

Total number of effective tillers were counted from all selected plants and averaged.

3.3.5 Length of the ear (cm)

Length of the three randomly selected ears from each plant was recorded in centimeter and averaged.

3.3.6 Number of spikelets per ear

Total number of spikelets in ear were counted from all selected plants and averaged.

3.3.7 Number of seeds per spike

Seeds of three randomly selected ear from each plant were counted and averaged.

3.3.8 Grain yield per plant (g)

Ears of each plant were threshed separately and total weight of seeds of all the selected plants was recorded in grams and averaged.

3.3.9 1000-grain weight (g)

One thousand seeds were counted from bulk sample of each replication and their weight was recorded in grams.

3.3.10 Biological yield per plant (g)

The total plant weight included straw and grain (minor root) was considered as the total biological yield per plants in grams.

3.3.11 Harvest index (%)

The harvest index is the ratio of grain yield to the total biological yield and was computed by the formula.

$$\text{Harvest Index} = \frac{\text{Grain yield per plant}}{\text{Biological yield per plant}} \times 100$$

3.3.12 Quality Characters

3.3.12.1 Malt percentage

For malting process, 100g barley (W_1) samples were taken for malting and the process of estimation was completed in the following three stages. Procedure followed for malt estimation is given hereunder.

Steeping

The grain sample was steeped in water for 10-12 hrs at 18^{0}C temperature to raise the moisture content up to 40-45 percent. In the second phase *i.e.,* after 24 hrs. of germination process again the samples were steeped for 4-5 hrs.

Germination

The samples were allowed to undergo the germination process for 96 hrs at 15^{0}C, to obtain the suitable malt modification i.e. the hydrolysis of the endosperm starch to sugars (Maltose and Fructose). The growth of plumule was taken as an indicator to stop the germination process.

Kilning

The samples after germination cycle were gradually kilning to dry the malt (bringing down the moisture content from 40-45% to 4.5 to 5.0%). The kilning process was completed in 24-28 hrs gradually raising the temperature from 30 to 80^{0}C, so as to completely dry the sample (W_1). The fragile dry roots were separated and remaining gramlar malt was weighed (W_2) in grams. The malt yield was calculated as

$$MY\ (\%) = \frac{W_1 - W_2}{W_1} \times 100$$

3.3.12.2 Starch percentage

Principle

Starch is extracted with perchloric acid after removal of sugars by extracting the sample flour with hot 70 percent alcohol. In hot acidic

medium starch is hydrolysed to glucose, dehydrated to hydroxymethyl furfural. This compound when reacts with anthrone, forms a green colour.

Procedure

(i) Extract oven dried sample flour (100 mg) with hot 70 percent ethanol. Centrifuge and retain the residue. Wash the residue with 70 percent hot ethanol. Dry the residue.

(ii) To the residue add 5.0 ml of water and 6.5 ml of 52 percent perchloric acid.

(iii) Shake the content for 5 minutes, centrifuge and collect the supernatant.

(iv) Repeat the extraction using 5 ml fresh perchloric acid for 10 minutes and centrifuge to collect the supernatant.

(v) Re-extracted the pellet using 5 ml fresh perchloric acid and shake for 30 minutes.

(vi) Pool the superntants and make up the volume to 100 ml with water.

(vii) Take suitable aliquot for glucose estimation. Add 5 ml of anthrone reagent. Heat on boiling water bath for 10 minutes.

(viii) Cool rapidly and read the intensity of colour formed at 620 nm.

(ix) Find out glucose content using the standard curve. Multiply the value by a factor 0.9 as 0.9g of starch yields 1g of glucose on hydrolysis.

3.4 STATISTICAL ANALYSIS

The statistical analysis was carried out for different traits recorded at different growth stages of genotypes. Estimation of mean, variance, coefficient of variation, heritability and genetic advance was done as per method described by different statiction are given below. The stability analysis was carried out in accordance with Eberhart and Russell (1966).

3.4.1 Analysis of variance (ANOVA)

Difference shown by the treatments (genotype) for various characters were tested for significance by using analysis of variance (ANOVA) technique.

Analysis of variance table

Source of variance	d. f.	M.S.	Expected M.S.	F
Replications	(r-1)	Sr	Msr	MSr/MSe
Treatment	(t-1)	St	Mst	MSt/MSe
Error	(r-1) (g-1)	Se	Mse	
Total	(rg-1)			

Where,

r = Number of replications or blocks.

t = Number of treatments or genotypes.

Mst = Variance due to genotypes.

Msr = Replications variance

Mse = Error mean square

3.4.2 Parameters of variability

3.4.2.1 Mean ($\overline{X}$)

The mean value of each character was worked out by dividing the totals by corresponding number of observations.

$$\overline{X} = \frac{SX_{ij}}{N}$$

Where,

X_{ij} = any observation in i^{th} genotype and j^{th} replication.

N = total number of observations.

3.4.2.2 Range

Lowest and highest values for character were recorded.

3.4.2.3 Standard Error

Standard error of difference of two means was calculated with the help of error mean square from the analysis of variance table.

Standard error (m±) = $\sqrt{2EMS/r}$

Where,

EMS = error mean sum of square.

r= number of replications

3.4.2.4 Critical Difference (C.D.)

Critical differences for all the characters were calculated to compare the treatment means. Critical differences were calculated with the help of standard error for the differences of two means and tabulated value of 't' at 5 percent level of significance and at error degree of freedom. Critical difference (C.D.) = SEd x t at 5 percent probability at error degree of freedom.

3.4.2.5 Coefficient of Variation

Genotypic and phenotypic coefficients of variation were estimated by the formula suggested by Burton and De Vane (1953) for each character as :

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{V_G}}{\bar{X}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sqrt{V_P}}{\bar{X}} \times 100$$

Where, $\bar{X}$ is the mean of that particular character and V_G and V_P are the genotypic and phenotypic variance, respectively.

3.4.2.6 Heritability in broadsense

Heritability in broad sense was calculated according to the formula suggested by Allard *et al.,* (1960) for each character :

$$H = \frac{V_G}{V_P} \times 100$$

3.4.2.7 Genetic advance expressed as percentage of mean

Estimates of appropriate variance components were substituted for the parameters to predict expected genetic gain as suggested by Allard (1960). The expected genetic advance was calculated at 5 percent selection intensity for each character as :

$$GA = (k)\ (\sigma^2 p)\ (H)$$

$$\text{Genetic advance (\% of mean)} = \frac{GA}{\overline{X}} \times 100$$

Where,

k K = Selection differential the value of which is 2.06 at 5% selection intensity.

H = Heritability in broad sense, and

$\sigma^2 P$ = Phenotypic standard deviation and

$\overline{X}$ = Mean value for that character over all the genotypes

3.4.3. Correlation Coefficient Analysis

Correlated characters are of interest to find out the genetic causes of correlation through the pleiotropic action of genes to know how selection for one character will cause simultaneous change in other characters and to find out correlation between character and fitness.

Phenotypic 'r (p)' correlation coefficients for all possible pairs of characters were calculated from the already obtained variance and covariances according to Johnson *et al.,* (1955).

The phenotypic correlation was measured by

$$\sigma\,(p) = \frac{\sigma_{XY}\,(p)}{\sqrt{\sigma_X^2\,(p) \times \sigma_Y^2\,(p)}}$$

Where,

$\sigma_{XY}\,(p)$ = Phenotypic covariances between character X and Y

$\sigma_x^2\,(p)$ = Phenotypic variance of character X

$\sigma_Y^2\,(p)$ = Phenotypic variance of character Y

The phenotypic correlation coefficients were tested against standardized tabulated significant value or 'r' with $(g-2)$ degrees of freedom as per the procedure described by Fisher and Yates (1963).

3.4.4. Path Coefficient Analysis

The correlation coefficients were used to work out path coefficient analysis. The estimates of direct and indirect effects of various characters were calculated through path coefficient analysis. Path coefficients were obtained according to Dewey and Lu (1959). A set of simultaneous equations in the following form were solved.

$$r_{ny} = p_{ny} + r_{n2}\ P_{2y} + r_{n3}\ P_{3y} \ldots\ldots\ldots\ldots\ldots + r_{nx}\ p_{xy}$$

Where,

r_{ny} = Correlation coefficient of one character and yield

p_{xy} = Path coefficient between the character and yield.

$r_{n2}, r_{n3} \ldots r_{nx}$ = Represent correlation coefficient of the character and each of other yield components in turn.

The following correlation matrices were formed :

Matrix A	Matrix B
r_{1y}	1 r_{12}, r_{13}.....r_{1n}
r_{2y}	1 r_{23}.....r_{2n}
r_{3y}	1.....r_{3n}
r_{ny}	1

The technique given by Goulden (1954) was followed for inversion of (B^{-1}) of B matrix.

Path coefficients P_{jy} were obtained as follows :

$$P_{jy} = (B^{-1}) \times (A)$$

The indirect effects for a particular character through other characters were obtained by multiplication of direct path and particular correlation coefficient between these two characters, respectively.

Indirect effect = $r_{ij} \times p_{iy}$

Where,

i = 1.....n

j = 1.....n

P_{jy} = P_{1y}, p_{2y}.....p_{ny}

r_{ij} = Correlation between two independent characters

The residual effect i.e. the variation in yield unaccounted for those associated was calculated from the following formula :

Residual effect $(\overline{X}) = \sqrt{1-R^2}$

Where,

$$R^2 = P_{1y}\, r_{1y} + P_{2y}\, r_{2y} + \ldots\ldots\ldots\ldots + P_{ny}\, r_{ny}$$

R^2, is the squared multiple correlation coefficient and is the amount of variation in yield that can be accounted for by the yield component characters.

3.4.5 Phenotypic Stability Analysis

The mean values recorded for different characters in respect of 40 genotypes in 8 environments as well as pooled over the environments, were used for analysis of variance for phenotypic stability. The methods of stability analysis used in this investigation followed the two approaches suggested by Eberhart and Russell (1966). The model used in these two different approaches are as follows :

3.4.5.1 Eberhart and Russell model (1966)

The approach is purely statistical one. The following model can be used to describe the performance of a variety over a series of, environments.

$$Y_{ij} = \mu_i + B_i\, l_j + \delta_{ij}$$

Where,

Y_{ij} = The variety mean of the i^{th} variety at the j^{th} environment

(Where, i = 1, 2.....g; j = 1, 2,.....b)

μ_i = Grand mean of the i^{th} genotype over all the environments

B_i = Regression coefficient that measure the linear response of the i^{th} genotype to varying environments.

l_j = Environmental index obtained as the mean of the genotype at the j^{th} environment minues the grand mean, *i.e.,*

$$l_j = \left(\sum_{i=1} Y_{ij} / g\right) - \left(\sum_i \sum_j Y_{ij} / gn\right)$$

Where,

$$\sum_j l_j = 0$$

δ_{ij} = is the deviation from regression slope of the i^{th} genotype in j^{th} environment

g = Number of genotypes

n = Number of environments

In this approach the model provides a mean of partitioning the genotype x environment interaction into two parts., *viz.,*

1. The variation due to the linear response of the genotype to varying environment indices (sum of square due to regression).

2. The unexplainable variations from the regression on the environmental index (S^2 di).

With this model, the sum of square due to environment and genotype-environment interactions are partitioned into environment (linear) and deviation from regression.

Analysis of variance for joint regression analysis as per model of Eberhart and Russell (1966).

Source of Variation	d.f.	Sum of square	MS
Genotypes (G)	g-1	$1/n \sum_j Y_i^2 - C.F.$	MS_1
Environment (E)	n-1		
G x E	(g-1) (n-1)g(n-1)	$\sum_i \sum_j Y_{ij}^2 - a Y_i^2 / n$	
E (linear)	1	$1/g \left(\sum_j Y_j l_j\right)^2 \sum_i l_j^2$	
G x E (linear)	g-1	$\sum_i \left(\sum Y_{ij} l_j\right)^2 \sum l_j^2 -$ Env. (L) S.S.	MS_2
Pooled deviation	g (n-2)	$\sum_i \sum_j \delta_{ij}^2$ (VSS – Regr S.S.)	MS_3
Genotype-1	n-2	$\left[\sum_j Y_{ij}^2 - (Y_g)^2/n\right] - \left[\sum_j Y_{ij} l_j\right]^2 / \sum_j l_j^2$	
Genotype-g	n-2	$\left[\sum_j Y_{gi}^2 - (Y_g)^2/n\right] - \left[\sum_j Y_{gi} l_j\right]^2 / \sum_j l_j^2$	-
Pooled error	n (g-1) (r-1)		S^2e

Where,

r, n and g indicate the number of replications, environments and genotypes, respectively. S^2e is the mean square due to pooled error which were calculates as :

$$S^2 e = \sum_j \left[S_j^2 / (r-1)\ (g-1)n\right] / r$$

Where,

S_j^2 = error sum of square at the j^{th} location Test of Significance.

I. The significance of difference among the genotype means i.e.

$H_0 : \mu_1 = \mu_2 = \ldots\ldots\ldots\ldots = \mu_g$

Can be tested by the 'F' test.

'F' = MS_1/MS_3

II. The hypothesis that there are no differences among genotypes for their regression on the environmental index.

$H_0 ; b_1 = b_2 = \ldots\ldots\ldots\ldots bg$

Can be tested approximately by the 'F' test

'F' = MS_2/MS_3

Note : MS_3 was tested against S^2e. In case MS_3 was non-significant, S^2e and MS_3 were pooled to test the remaining sources of variation.

3.4.5.1.1. Estimation of stability parameters for individual genotypes

The stability parameters of individual genotypes were calculated as suggested by Eberhart and Russell (1966) which are described below :

A. Mean (μ)

The mean value of i^{th} genotype over all the environments was simply calculated by taking the mean of the genotype over all the environments i.e.

$$\mu = a_j \; Y_{ij} / N$$

B. Regression coefficient (b_i)

The coefficient of regression (b_i) of the performance of each genotype in various environments on the environmental indices over all the genotypes under study was calculated as :

$$bi = \sum_j Y_{ij} \; l_j / \sum_j l_j^2$$

C. Deviation from regression (S^2di)

The deviation from linear regression (S^2di) was calculated as given below :

$$S^2di = \left[\sum_j (d_{ij}^2/(n-2)\right] - S^2e/r$$

Where,

S^2e/r = the estimate of pooled error (or variance of a variety mean at the j^{th} location) and

$$\sum_j d_{ij}^2 = \left[\sum_j Y_{ij}^2 - (Y_i)^2/n\right] - \left[\sum_j Y_{ij}\, l_j\right]^2 / \sum_j l_j^2$$

3.4.5.1.2 Test of significance

1. Testing of b_j

The hypothesis that any regression coefficient does not differ from unity is tested by appropriate 't' test.

$$'t' = (b_j - 1)/SE(b_j) \text{ at } (n-2) \text{ d.f.}$$

$$\text{S.E. } (b_j) = \frac{\sqrt{\text{M.S. due to pooled deviation of } i^{th} \text{ variety}}}{\sum_j l_j^2}$$

Where,

M.S. due to pooled deviation of i^{th} variety = $d_{ij}^2/n-2$ with n-2 d.f.

2. Significance of deviation from regression S^2di was tested by calculating 'F' value.

$$'F' = \left(\sum_j \delta_{ij}^2/n-2\right)/S^2e \text{ at } (n-2) \text{ and } n(r-1)(g-1) \text{ d.f.}$$

Chapter-IV

Experimental Findings

The success of any breeding programme depends on the magnitude of genetic variability present in the populations which leads to effective selection. It is imperative to assess the relative magnitude of components of variability, heritability, genetic advance and the extent of character association among grain yield per plant and its component characters. Very little attention is given on these aspects in barley and therefore, present investigation was undertaken to assess different parameters of genetic variability and the extent of character association between grain yield per plant and its components characters.

4.1 ASSESSMENT OF VARIABILITY

The results pertaining the analysis of variance (ANOVA) for 13 characters in 40 genotypes of barley (*Hordeum vulgare* L.) for both the years are given In Table-1. ANOVA revealed that the mean sum of squares (MSS) due to treatments were significant for twelve traits in environments I, III, IV, V, VII and VIII as well as in pooled analysis (Table-2) and in environments II and VI mean squares (MSS) due to treatments were significant for all the thirteen traits, indicating the presence of considerable genetic variability in the genotypes under study.

4.1.1 Mean performance and range of variability

The results of mean performance for 13 traits of 40 genotypes of barley have been presented in Table-3 to 11, whereas, results regarding the phenotypic coefficient of variation (PCV) and genotypic coefficient of

Table-1 : Analysis of variance for thirteen characters in forty genotypes of barley.

Source	D.F.	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per ~~plant~~ ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Environment-I														
Replication	2	19.37	52.00	-0.12	0.26	1.12	28.65	0.34	0.10	1.95	0.64	3.86	516.34	270.54
Treatment	39	41.82**	38.19**	48.97**	5.71**	0.30	82.50**	71.82**	3.21**	18.45**	21.59**	59.36**	15.35**	7.52**
Error	78	9.61	18.57	14.42	8.73	9.32	4.88	4.06	0.13	0.90	0.82	4.45	0.83	0.51
Environment-II														
Replication	2	1.06	10.00	1.43	0.34	4.73	17.04	0.00	0.54	1.63	7.81	3.51	507.00	304.10
Treatment	39	32.84**	21.37**	51.96**	6.59**	0.33**	82.67**	62.58**	3.29**	17.14**	18.44**	62.73**	15.63**	6.29**
Error	78	11.83	20.37	15.42	0.13	0.10	5.32	4.39	0.18	0.96	0.99	1.51	0.81	0.48
Environment-III														
Replication	2	11.75	7.00	13.75	3.22	9.08	1.96	3.59	6.59	1.68	8.20	0.24	462.65	261.51
Treatment	39	26.67**	44.59**	39.20**	4.09**	0.70	74.13**	60.49**	3.64**	15.83**	18.78	59.00**	15.96**	3.56**
Error	78	10.48	17.88	14.02	7.87	8.48	4.60	3.53	0.11	0.87	0.73	0.22	0.67	0.42
Environment-IV														
Replication	2	4.15	20.75	7.43	8.78	4.56	4.07	1.53	0.11	0.37	0.32	0.15	50.03	302.90
Treatment	39	33.76**	37.24**	40.28**	4.81**	0.49	111.11**	67.61**	3.99**	15.42**	18.63	64.55**	16.15**	42.06**
Error	78	10.67	19.36	14.57	0.11	9.28	4.08	3.81	0.13	0.93	0.83	0.13	0.87	0.48

Table-1 Contd.....

Table-1 Contd.....

Source	D.F.	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Environment-V														
Replication	2	11.68	43.50	1.75	0.25	2.24	32.71	0.59	1.60	0.42	2.42	2.64	310.68	166.68
Treatment	39	36.75**	35.20**	52.02**	5.88**	0.37	84.89**	69.74**	3.45**	18.75**	19.88**	59.80**	22.43**	6.85**
Error	78	9.47	17.07	16.72	8.89	9.84	3.25	3.80	0.23	0.85	1.27	5.09	4.06	4.52
Environment-VI														
Replication	2	1.90	4.31	1.56	0.24	53.71	24.42	0.85	0.68	1.87	0.21	5.74	369.06	239.32
Treatment	39	30.54**	21.74**	46.90**	6.64**	0.34**	84.28**	62.85**	3.34**	17.31**	17.58**	69.12**	13.71**	5.65**
Error	78	13.65	18.17	16.92	0.14	0.10	7.01	5.13	0.17	0.94	1.18	2.37	4.20	1.52
Environment-VII														
Replication	2	42.59	5.12	6.68	8.30	0.15	4.98	4.31	5.51	2.60	9.37	4.73	364.81	287.17
Treatment	39	27.78**	39.96**	33.05**	4.06**	0.70	66.09**	60.35**	3.80**	16.92**	18.87**	57.25**	15.15**	4.10*
Error	78	9.56	14.74	15.05	9.78	8.52	5.83	3.75	0.13	0.88	1.20	1.68	2.08	0.74
Environment-VIII														
Replication	2	10.25	23.06	3.06	0.11	4.34	4.14	2.28	0.11	0.48	0.46	0.14	431.12	289.35
Treatment	39	33.78**	34.37**	45.73**	5.14**	0.49	119.35**	64.31**	4.00**	14.78**	17.64**	74.37**	14.79**	41.44**
Error	78	11.61	18.17	17.74	0.12	9.60	4.08	4.47	0.13	0.97	1.06	1.55	1.51	0.52

*, ** Significant at 5 and 1 % levels, respectively.

Table-2 : Analysis of variance for thirteen characters in forty genotypes of barley (pooled analysis).

Source	D.F.	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Location	7	784.00	1044.33	573.83	122.55	10.72	1768.89	865.87	140.60	32.13	287.14	357.04	257.66	383.50
Replication	2	3.50	67.25	8.25	8.98	0.13	44.93	2.68	0.39	3.59	0.62	1.03	1720.37	1052.18
L x R	14	14.75	4.91	3.08	0.20	1.59	4.20	1.06	0.13	0.26	0.38	2.83	1.58	1.33
Treatment	39	111.69**	100.54**	149.29**	17.99**	1.02	228.49**	218.02**	10.24**	64.45**	66.28**	172.24**	21.36**	19.81**
L x T	273	6.06	11.50	8.89	1.14	0.27	40.66	13.62	1.36	0.84	2.87	26.16	12.36	12.64
Error	**624**	**10.40**	**17.86**	**14.91**	**0.10**	**9.00**	**4.89**	**3.93**	**0.14**	**0.88**	**0.92**	**1.82**	**1.30**	**0.75**

*, ** Significant at 5 and 1 % levels, respectively.

variation (GCV) are given In Table 12 and 13, respectively. These results are reviewed here under character wise

1. Days to 50 per cent flowering

The range of this trait recorded for earliness (85.00 days) in K-370 in environment-IV and for late flowering in Jyoti (103.00 days) in environment-II and K-273 (103.00 days) in environment-VI. The trait days to 50 per cent flowering showed wide range of variation and some accessions were observed for their stable performance across the environments. However, in pooled analysis accession K-252 was found early (88.18 days) and K-141 was late in flowering (100.03 days) as compared to grand mean 94.53 ± 2.620.

Regarding phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), the PCV (4.81) and GCV (3.49) was found higher for this trait in environment and lower PCV (4.25) in environment-VII and lower GCV (2.59) in environment-VI. Pooled analysis showed that this trait had the little difference between PCV (4.64) and GCV (3.14).

2. Days to maturity

Accession K-633 was earliest in maturity (108.50 days) in environment-III and accession K-791 was found late in maturity (133.34 days) in environment-VI. On the basis of pooled analysis, early maturity (117.28 days) was observed for accession K-633 followed by Vijaya (120.41 days) and Jagrati (120.80 days), while late maturity was observed in K-783 (129.12 days). The general mean (124.33 ± 3.423) was recorded indicating sufficient magnitude of variability days to maturity.

Table-3 : Mean performance of forty genotypes of barley in environment-I .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	94.33	119.33	113.33	7.33	8.30	60.78	56.67	9.00	24.67	28.67	31.45	91.00	57.12
2	K-273	97.67	123.67	104.33	9.90	8.60	64.35	60.67	11.33	26.33	30.33	37.41	78.03	58.81
3	Manjula	96.00	123.67	111.03	8.16	9.30	63.44	54.00	10.37	25.20	23.11	44.95	78.00	55.01
4	K-678	95.00	122.00	103.30	7.89	8.70	65.67	61.00	11.33	25.50	25.00	45.32	81.07	57.80
5	Vijaya	88.33	118.67	104.66	6.61	8.89	53.33	47.33	9.78	25.22	21.89	44.76	75.00	56.02
6	Jagrati	90.33	119.33	117.67	8.97	8.70	53.78	47.00	8.79	24.00	18.80	46.76	83.09	56.75
7	Jyoti	101.00	127.00	106.03	8.41	7.80	56.67	53.00	9.00	25.00	19.00	47.46	79.00	57.14
8	PL—781	91.67	120.00	110.11	7.44	8.00	65.00	56.67	11.17	30.33	26.00	42.96	78.03	59.65
9	K-169	89.67	120.00	106.20	10.44	8.21	60.11	56.78	11.30	30.17	28.00	40.43	78.00	57.68
10	K-252	89.67	118.33	106.00	10.33	8.50	64.39	60.39	11.44	24.44	28.78	39.75	80.05	55.60
11	BH-851	97.67	125.33	102.22	8.55	8.61	60.11	55.11	11.83	25.00	28.22	41.98	80.00	58.38
12	K-370	86.33	120.00	111.67	8.33	8.66	66.22	55.44	10.83	30.33	23.33	46.51	83.09	59.41
13	K-729	94.33	124.67	106.50	6.32	8.39	70.00	60.00	9.89	31.00	24.28	40.81	83.00	59.40
14	BEU-73	96.67	128.67	113.47	7.64	8.24	64.22	61.33	11.83	27.89	23.11	49.09	78.03	60.84
15	K-341	91.67	120.00	102.89	6.94	8.19	60.78	58.33	11.11	29.89	26.89	41.32	77.00	54.10
16	K-603	95.00	120.00	105.78	9.89	8.50	66.22	59.33	8.33	30.00	25.35	32.86	78.03	57.68
17	K-683	99.00	128.33	106.94	10.94	9.03	77.11	62.33	10.55	25.43	29.17	36.17	76.00	57.04
18	K-792	95.00	121.00	105.44	9.89	8.33	62.22	55.00	11.61	29.55	27.00	43.00	78.25	57.84
19	K-784	92.67	121.67	101.67	11.28	8.69	68.05	59.67	11.50	30.78	24.67	46.70	80.48	59.38
20	K-409	93.67	125.67	108.33	8.61	8.94	62.33	50.67	9.70	24.67	25.33	38.29	79.67	59.07
21	K-1149	95.00	126.33	113.67	8.05	8.19	60.21	53.33	10.33	25.22	24.11	42.85	75.02	59.39
22	K-551	93.33	118.33	110.22	10.17	9.00	61.61	52.00	9.13	24.33	23.16	39.42	80.91	57.02

Table-3 Contd.....

Table-3 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	92.00	123.33	104.39	10.33	8.54	63.55	51.63	10.11	30.33	25.17	40.17	81.49	56.35
24	Lakhan	89.67	125.00	106.94	9.89	9.05	61.00	53.10	12.00	25.50	24.55	48.88	79.32	57.82
25	K-804	91.67	118.33	113.50	9.78	8.39	65.72	50.55	10.05	25.30	23.55	42.68	81.11	60.42
26	RD-2035	94.00	120.00	102.43	10.50	8.90	62.33	58.55	11.55	29.22	26.89	42.95	80.31	55.74
27	K-318	100.00	127.00	106.89	8.90	8.64	72.89	60.24	10.89	25.22	26.22	41.59	82.45	57.61
28	K-1155	94.33	123.00	109.55	7.70	8.33	70.11	62.22	10.78	24.44	28.50	37.87	78.69	50.78
29	K-789	96.33	126.67	110.28	8.44	8.66	58.22	53.72	9.71	30.33	23.50	41.53	81.19	59.60
30	K-633	87.67	114.67	113.50	10.22	8.33	63.44	53.00	10.55	24.22	25.44	41.53	82.62	57.06
31	K-791	96.67	123.33	110.22	11.83	8.66	65.55	57.83	11.83	25.50	28.89	41.02	82.40	57.90
32	K-794	97.67	127.00	106.39	9.78	8.66	67.50	55.89	11.78	28.44	27.33	43.16	80.68	60.41
33	Amber	87.33	118.33	107.05	7.79	8.78	75.44	67.55	9.80	25.55	27.89	35.14	79.13	56.61
34	K-675	94.33	125.00	111.78	9.22	8.77	64.28	55.67	11.55	24.87	24.72	46.72	80.91	58.69
35	K-141	99.33	127.33	102.55	10.00	8.66	70.17	67.33	8.79	29.28	26.72	32.96	83.72	57.82
36	K-508	93.34	120.67	111.47	7.61	7.91	65.53	56.55	11.10	27.89	26.50	42.63	78.77	57.13
37	K-745	92.00	118.56	104.66	6.47	8.08	61.47	56.45	11.96	29.51	26.39	47.42	80.07	56.20
38	K-713	96.34	120.33	107.00	8.43	8.91	66.67	60.00	8.75	29.88	26.00	33.82	76.80	56.00
39	DL-65	98.43	126.33	109.16	8.77	9.50	72.32	62.32	10.30	26.00	29.00	35.37	79.20	57.87
40	DL-88	93.66	122.00	105.23	7.91	8.50	61.58	49.89	11.05	30.00	27.50	40.98	80.80	58.13
	Range	**86.33**	**114.67**	**101.67**	**6.32**	**7.80**	**53.33**	**47.00**	**8.33**	**24.00**	**18.80**	**31.45**	**75.00**	**50.78**
		101.00	**128.67**	**117.67**	**11.83**	**9.30**	**77.11**	**67.55**	**12.00**	**31.00**	**30.33**	**48.88**	**83.72**	**60.84**
	SED	**2.53**	**3.51**	**3.10**	**0.24**	**0.25**	**1.00**	**1.64**	**0.30**	**0.77**	**0.74**	**1.72**	**0.74**	**0.58**
	Grand Mean	**93.85**	**122.60**	**107.91**	**9.04**	**8.58**	**64.19**	**56.36**	**10.54**	**26.94**	**25.53**	**41.61**	**79.83**	**57.88**
	CD at 5 %	**5.03**	**6.98**	**6.16**	**0.48**	**0.50**	**3.58**	**3.26**	**0.60**	**1.60**	**1.47**	**3.42**	**1.47**	**1.15**

Table-4 : Mean performance of forty genotypes of barley in environment-II .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	96.00	126.67	116.58	9.10	8.60	63.66	60.00	13.80	25.58	29.46	46.84	82.84	59.03
2	K-273	100.67	128.33	105.33	11.03	8.88	65.66	62.00	13.13	26.87	32.04	40.98	83.86	58.70
3	Manjula	99.33	127.67	113.44	9.17	9.87	64.11	55.16	13.13	25.51	26.66	50.00	81.68	60.89
4	K-678	98.00	127.67	106.78	8.40	8.97	64.89	62.55	12.24	26.66	27.00	45.39	82.64	62.54
5	Vijaya	92.00	121.67	104.55	8.41	9.00	53.00	51.72	12.44	25.58	27.53	45.19	82.01	59.86
6	Jagrati	94.33	123.33	119.83	10.50	9.33	54.67	51.07	11.17	25.33	22.66	49.39	84.74	59.83
7	Jyoti	103.00	130.33	108.11	9.13	8.50	64.89	60.17	11.89	25.17	23.97	49.60	79.21	61.81
8	PL—781	96.33	125.67	112.89	8.20	8.55	67.66	52.00	12.00	30.89	28.97	41.42	83.16	61.14
9	K-169	94.00	121.67	107.89	11.66	8.66	63.50	55.44	13.05	30.17	30.33	43.03	78.70	60.47
10	K-252	94.67	125.67	108.88	12.11	8.80	64.00	61.66	12.48	25.33	31.77	39.28	83.84	58.02
11	BH-851	100.00	130.33	106.00	10.78	8.78	64.00	64.66	13.44	27.00	32.89	40.86	80.18	59.00
12	K-370	92.33	124.67	115.22	10.11	9.00	60.33	56.33	11.28	30.33	25.33	44.53	84.75	63.28
13	K-729	98.00	126.67	108.57	8.22	9.30	64.78	61.44	10.80	31.67	26.00	41.54	82.81	59.40
14	BEU-73	99.00	130.33	115.22	9.07	9.78	66.11	63.33	11.44	28.89	27.71	41.28	84.86	60.12
15	K-341	93.67	124.67	106.83	8.77	8.41	70.67	59.22	12.00	30.44	30.20	39.74	81.80	58.07
16	K-603	98.33	124.67	112.17	12.22	8.73	65.55	61.11	10.43	30.33	27.00	38.63	80.58	60.74
17	K-683	100.67	131.00	113.70	12.78	9.43	57.55	53.78	11.70	25.67	32.00	36.56	79.40	58.79
18	K-792	98.00	126.67	107.44	11.83	9.11	61.44	57.33	12.64	30.58	29.33	43.16	82.61	57.24
19	K-784	94.33	124.00	103.50	13.00	9.00	70.00	63.89	13.00	31.00	26.00	50.00	79.67	59.71
20	K-409	98.00	128.00	113.57	11.89	9.00	65.00	55.33	9.70	25.00	28.00	34.69	80.10	60.90
21	K-1149	99.33	129.33	115.00	8.78	8.89	63.00	60.33	11.44	26.67	28.00	40.86	79.12	58.80
22	K-551	96.00	126.67	113.33	11.22	9.11	62.00	57.17	11.13	24.33	26.89	41.39	83.16	57.09

Table-4 Contd.....

Table-4 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant/ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	100.67	129.67	106.83	11.89	8.87	65.00	58.78	12.83	31.67	26.33	48.73	83.40	61.83
24	Lakhan	94.67	124.33	110.22	10.17	9.16	62.00	55.00	13.89	26.89	25.66	54.13	82.14	61.17
25	K-804	94.00	128.67	115.22	10.53	8.63	67.00	62.50	13.33	26.00	28.11	47.42	85.74	60.61
26	RD-2035	99.67	126.67	104.72	11.83	9.17	65.00	60.78	12.77	29.55	29.89	42.72	79.85	59.76
27	K-318	101.00	129.33	113.69	9.50	8.67	75.00	61.66	12.77	26.91	28.10	45.44	80.05	58.77
28	K-1155	95.00	128.67	112.17	8.55	8.67	73.00	63.67	12.44	25.27	31.53	39.45	77.23	62.06
29	K-789	100.00	130.33	113.00	10.37	9.16	62.00	55.44	10.70	30.55	24.72	43.28	83.42	58.62
30	K-633	90.33	122.33	115.44	11.50	9.01	75.00	58.55	12.44	26.66	26.00	47.85	80.77	60.51
31	K-791	100.00	130.67	113.83	12.08	9.47	55.00	52.24	12.67	26.67	31.00	40.87	84.75	59.38
32	K-794	99.67	127.33	110.20	10.28	9.03	69.00	58.22	13.33	28.67	29.67	44.99	81.19	61.03
33	Amber	91.33	124.67	112.53	9.03	8.92	77.00	70.03	10.18	25.22	30.33	33.56	78.07	58.69
34	K-675	99.00	128.33	116.67	11.03	9.03	76.00	58.46	12.00	25.00	26.53	45.23	81.32	60.41
35	K-141	102.67	129.33	106.67	12.55	8.67	72.00	70.33	11.67	30.78	29.03	40.26	79.45	60.30
36	K-508	95.67	126.67	110.16	9.27	8.91	73.00	61.89	12.96	31.77	31.87	39.74	83.53	59.08
37	K-745	100.33	126.67	115.50	12.66	9.23	67.88	63.44	11.35	31.33	28.00	39.30	83.00	61.50
38	K-713	98.99	133.30	116.03	13.22	9.90	60.65	56.42	12.60	26.67	33.33	38.66	80.87	59.57
39	DL-65	99.91	128.67	110.68	12.30	9.61	63.77	59.66	13.58	31.58	31.33	45.16	83.40	61.50
40	DL-88	96.00	126.67	107.20	13.50	9.53	70.33	66.22	13.94	32.00	28.00	53.00	81.20	60.80
	Range	**90.33**	**121.67**	**103.50**	**8.20**	**8.41**	**53.00**	**51.72**	**9.70**	**24.33**	**22.66**	**33.56**	**77.23**	**57.09**
		103.00	**131.00**	**119.83**	**13.00**	**9.87**	**77.00**	**70.33**	**13.89**	**31.67**	**32.89**	**54.13**	**85.74**	**63.28**
	SED	**2.80**	**3.68**	**3.20**	**0.30**	**0.26**	**1.88**	**1.71**	**0.34**	**0.80**	**0.81**	**1.00**	**0.73**	**0.56**
	Grand Mean	**97.25**	**127.01**	**111.02**	**10.46**	**8.97**	**65.44**	**59.49**	**12.15**	**27.67**	**28.18**	**43.37**	**81.74**	**59.95**
	CD at 5 %	**5.57**		**6.37**	**0.60**	**0.52**	**3.74**	**3.40**	**0.68**	**1.59**	**1.61**	**1.99**	**1.45**	**1.11**

Table-5 : Mean performance of forty genotypes of barley in environment-III .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	89.33	118.67	110.52	6.27	8.39	53.66	52.32	7.66	23.00	24.44	31.34	79.66	57.42
2	K-273	90.00	120.67	101.00	8.99	8.39	62.33	56.66	9.70	25.66	27.83	34.85	79.18	53.63
3	Manjula	93.33	110.33	104.17	7.28	8.33	60.89	48.77	8.61	25.00	22.17	38.84	77.87	55.63
4	K-678	90.00	122.67	102.50	7.69	8.30	58.39	53.33	10.80	25.10	23.05	46.85	78.65	54.09
5	Vijaya	88.33	117.67	103.83	6.50	8.83	50.78	46.31	7.90	24.77	19.20	41.15	81.14	56.39
6	Jagrati	87.67	116.67	111.78	6.20	8.33	51.44	46.25	7.55	24.00	17.00	44.41	81.69	54.01
7	Jyoti	95.67	125.67	105.94	8.08	7.50	53.00	52.00	8.00	25.00	18.17	44.03	79.04	54.74
8	PL—781	90.67	118.67	105.39	7.33	7.29	63.51	52.33	10.39	30.29	24.44	42.51	77.36	56.04
9	K-169	87.67	118.00	104.00	8.43	7.83	55.00	49.27	10.43	28.33	26.50	39.36	78.75	55.79
10	K-252	89.33	116.50	103.50	8.55	6.72	61.44	56.28	10.05	24.00	25.55	39.33	75.01	53.79
11	BH-851	95.00	124.33	100.28	8.45	8.11	59.80	53.44	11.89	25.00	26.39	45.05	79.66	56.00
12	K-370	86.00	118.00	105.22	7.10	8.55	61.55	49.89	9.50	29.33	23.00	41.30	78.04	55.04
13	K-729	91.67	123.67	105.11	6.55	8.00	66.22	55.44	8.55	29.67	20.95	45.58	77.57	57.82
14	BEU-73	91.67	118.41	108.80	7.07	7.41	59.53	54.22	10.00	26.89	24.50	40.82	77.82	56.35
15	K-341	90.00	115.33	100.33	6.00	7.58	58.47	54.78	11.03	28.51	24.39	45.22	79.02	55.34
16	K-603	94.67	118.00	103.67	8.00	8.41	64.00	58.00	7.84	28.55	24.80	31.61	75.66	52.72
17	K-683	96.33	124.33	105.83	8.66	9.00	70.66	60.32	9.37	24.00	27.00	37.70	78.07	56.67
18	K-792	92.33	120.00	101.66	7.46	8.00	58.91	47.89	10.11	28.00	25.50	39.65	79.62	56.79
19	K-784	90.33	116.61	100.44	11.11	8.00	64.55	46.67	9.91	29.11	23.11	42.88	76.81	55.76
20	K-409	93.33	119.31	106.55	6.89	8.33	56.33	48.22	8.73	24.00	24.33	35.88	74.07	54.78
21	K-1149	91.67	120.00	112.50	7.50	7.97	55.00	50.11	9.44	25.00	33.66	39.90	80.67	57.02
22	K-551	90.00	116.46	105.40	8.82	8.23	61.44	49.13	7.55	24.00	21.00	35.95	77.04	56.67

Table-5 Contd.....

Table-5 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant (g)	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	90.00	116.19	101.44	9.66	8.19	57.13	47.78	9.24	29.10	24.91	37.09	77.01	55.53
24	Lakhan	88.67	118.71	103.53	7.13	8.50	58.91	50.33	10.39	24.80	23.78	43.69	77.43	55.07
25	K-804	90.67	116.00	110.83	7.85	8.64	65.00	47.64	9.66	25.00	27.33	35.35	78.91	56.78
26	RD-2035	90.00	120.30	100.89	9.93	8.66	54.66	53.55	9.89	29.00	24.30	40.70	81.26	53.62
27	K-318	98.67	126.67	105.95	7.38	8.46	64.91	56.91	8.12	25.10	24.66	32.93	78.09	54.07
28	K-1155	90.33	120.00	108.44	7.00	8.00	64.97	56.44	9.44	23.90	27.63	34.17	76.32	57.48
29	K-789	93.33	123.33	109.89	7.50	8.66	55.47	50.55	9.11	30.10	22.33	40.80	76.93	55.07
30	K-633	86.67	108.50	110.80	8.77	7.67	59.61	49.44	9.80	24.00	24.89	39.37	79.07	56.07
31	K-791	90.33	118.56	108.97	9.78	8.33	62.11	56.55	10.53	25.70	26.33	40.05	75.07	55.00
32	K-794	90.00	120.00	105.02	8.00	8.78	66.27	52.97	10.00	29.55	25.69	38.93	78.65	55.03
33	Amber	86.67	118.33	102.00	6.17	8.00	70.78	62.66	8.80	24.58	24.39	36.08	74.03	54.79
34	K-675	90.00	120.00	110.78	7.83	8.77	59.22	54.63	10.78	24.00	23.44	45.99	80.61	55.09
35	K-141	96.67	125.00	104.11	8.22	8.44	64.32	63.44	7.95	28.05	25.66	30.98	77.95	54.78
36	K-508	92.00	118.56	104.66	6.47	8.08	61.47	56.45	11.96	29.51	26.39	47.42	80.07	56.20
37	K-745	96.34	120.33	107.00	8.43	8.91	66.67	60.00	8.75	29.88	26.00	33.82	76.80	56.00
38	K-713	98.43	126.33	109.16	8.77	9.50	72.32	62.32	10.30	26.00	29.00	35.37	79.20	57.87
39	DL-65	93.66	122.00	105.23	7.91	8.50	61.58	49.89	11.05	30.00	27.50	40.98	80.80	58.13
40	DL-88	92.00	119.34	103.77	11.64	8.50	66.88	50.00	10.88	30.78	24.44	44.55	78.13	57.63
	Range	**86.00**	**108.50**	**100.28**	**6.00**	**6.72**	**50.78**	**46.25**	**7.55**	**23.00**	**17.00**	**31.34**	**74.03**	**52.72**
		98.67	**126.67**	**111.78**	**11.11**	**9.00**	**70.78**	**63.44**	**11.89**	**30.29**	**27.83**	**46.85**	**81.69**	**57.82**
	SED	**2.64**	**3.45**	**3.05**	**0.22**	**0.23**	**1.75**	**1.53**	**0.27**	**0.76**	**0.69**	**0.38**	**0.67**	**0.53**
	Grand Mean	**91.05**	**119.21**	**105.45**	**7.83**	**8.18**	**60.29**	**52.72**	**9.42**	**26.29**	**24.06**	**39.35**	**78.25**	**55.56**
	CD at 5 %	**2.25**	**6.87**	**6.07**	**0.44**	**0.46**	**3.48**	**3.04**	**0.54**	**1.51**	**1.37**	**0.76**	**1.33**	**1.05**

Table-6 : Mean performance of forty genotypes of barley in environment-IV .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	88.33	122.67	103.00	8.83	8.30	51.11	48.31	8.11	24.66	25.33	32.02	81.69	59.00
2	K-273	90.00	124.33	103.00	9.22	8.20	53.00	47.83	10.78	25.33	29.66	36.35	76.72	56.82
3	Manjula	91.67	125.00	110.20	8.14	9.60	53.67	50.33	9.11	25.66	23.88	38.15	81.69	59.81
4	K-678	91.00	124.33	101.89	7.22	8.94	51.22	46.22	11.89	25.33	24.80	47.91	80.74	57.56
5	Vijaya	90.33	118.33	104.72	6.89	8.53	44.67	40.11	8.89	25.00	21.00	39.67	77.06	57.04
6	Jagrati	91.67	119.00	112.39	10.17	8.66	50.44	48.12	8.33	25.22	20.17	47.10	81.82	58.41
7	Jyoti	96.67	128.67	103.17	8.13	8.00	54.89	45.89	9.50	26.00	20.22	45.35	77.11	60.51
8	PL—781	94.00	124.00	109.89	8.05	8.11	55.11	48.66	9.17	31.00	26.33	34.68	81.94	58.04
9	K-169	90.00	115.40	106.11	10.22	8.12	51.33	47.33	9.13	29.22	27.78	42.12	77.05	57.91
10	K-252	90.00	124.00	106.00	10.89	8.33	50.17	42.44	11.70	25.33	27.22	42.43	85.33	61.04
11	BH-851	95.33	126.15	103.33	8.43	8.38	51.66	45.45	11.55	25.25	28.78	42.46	79.05	59.11
12	K-370	85.00	119.00	110.00	9.33	8.66	57.83	50.33	12.22	30.10	23.13	45.09	80.13	79.71
13	K-729	92.67	124.12	114.44	7.66	8.90	51.78	47.33	10.43	30.00	22.44	45.90	83.41	59.74
14	BEU-73	95.33	128.80	110.00	8.05	9.11	59.39	55.00	10.30	27.22	26.11	39.56	81.70	58.80
15	K-341	89.67	120.00	103.44	7.39	8.00	64.11	56.11	10.33	29.33	27.33	43.91	77.93	57.42
16	K-603	92.67	118.33	110.00	11.00	8.66	54.33	50.11	12.00	30.47	26.44	30.67	76.31	57.61
17	K-683	95.00	129.30	110.39	10.61	9.10	55.55	51.66	8.11	24.67	29.22	36.48	81.10	59.33
18	K-792	94.33	123.90	105.55	9.83	8.83	60.33	48.78	10.66	29.55	26.55	42.07	80.62	58.91
19	K-784	92.33	123.33	100.33	11.00	8.83	60.11	48.78	11.17	30.89	24.83	42.05	79.08	57.82
20	K-409	92.33	127.80	110.33	8.94	8.89	43.17	41.33	10.44	25.11	7.18	33.87	79.05	57.06
21	K-1149	94.33	126.00	109.55	7.00	8.00	51.55	44.19	9.22	26.11	24.44	41.37	80.03	60.02
22	K-551	90.00	123.00	109.55	9.22	8.89	60.66	51.72	8.44	25.67	22.00	38.36	79.06	59.38

Table-6 Contd.....

Table-6 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	93.67	125.50	101.55	9.67	8.11	63.89	49.00	10.55	30.78	26.00	40.58	80.10	57.02
24	Lakhan	88.33	120.00	108.11	10.33	8.22	59.33	52.83	10.50	25.78	25.50	41.27	82.34	57.82
25	K-804	89.67	127.00	110.73	9.89	8.61	65.33	49.33	10.44	26.22	28.60	36.57	84.17	59.87
26	RD-2035	95.00	124.84	103.11	10.28	8.30	57.33	52.57	10.30	29.11	25.89	39.78	81.82	59.84
27	K-318	97.00	128.33	107.22	8.94	8.61	70.33	59.89	9.11	26.22	25.44	35.81	77.54	57.80
28	K-1155	89.67	124.67	108.55	8.00	8.66	68.66	59.11	10.23	25.20	28.67	35.68	82.12	60.72
29	K-789	93.33	127.67	109.00	9.66	8.28	57.55	51.00	10.21	31.11	24.00	42.54	78.61	58.38
30	K-633	85.00	118.33	110.83	10.17	9.00	57.78	50.67	10.22	25.80	26.17	39.05	79.03	59.44
31	K-791	96.67	126.18	110.44	11.85	8.18	54.44	50.21	11.44	25.33	28.30	40.38	82.10	58.12
32	K-794	95.33	125.00	108.44	9.22	8.63	58.66	53.66	10.83	28.67	27.55	39.31	83.13	58.74
33	Amber	85.67	120.21	106.00	8.66	8.22	55.72	50.10	9.44	25.44	26.22	36.00	77.62	58.81
34	K-675	94.33	124.00	112.78	9.94	7.89	63.20	56.78	11.89	25.02	24.44	48.65	78.06	56.84
35	K-141	98.00	126.69	103.33	10.55	8.44	62.00	57.00	8.66	29.22	28.44	30.49	78.06	58.32
36	K-508	91.67	120.00	102.89	6.94	8.19	60.78	58.33	11.11	29.89	26.89	41.32	77.00	54.10
37	K-745	95.00	120.00	105.78	9.89	8.50	66.22	59.33	8.33	30.00	25.35	32.86	78.03	57.68
38	K-713	99.00	128.33	106.94	10.94	9.03	77.11	62.33	10.55	25.43	29.17	36.17	76.00	57.04
39	DL-65	95.00	121.00	105.44	9.89	8.33	62.22	55.00	11.61	29.55	27.00	43.00	78.25	57.84
40	DL-88	92.67	121.67	101.67	11.28	8.69	68.05	59.67	11.50	30.78	24.67	46.70	80.48	59.38
	Range	**85.00**	**115.40**	**100.33**	**6.89**	**7.89**	**43.17**	**40.11**	**8.11**	**24.66**	**20.17**	**30.49**	**76.31**	**56.82**
		98.00	**129.30**	**114.44**	**11.85**	**9.60**	**70.33**	**59.89**	**12.22**	**31.11**	**29.66**	**48.65**	**84.17**	**79.71**
	SED	**2.66**	**3.59**	**3.11**	**0.27**	**0.24**	**1.64**	**1.59**	**0.29**	**0.78**	**0.74**	**0.29**	**0.76**	**0.57**
	Grand Mean	**92.12**	**123.84**	**107.35**	**9.23**	**8.54**	**56.58**	**54.90**	**10.18**	**27.18**	**25.71**	**39.82**	**80.09**	**59.22**
	CD at 5 %	**5.29**	**7.14**	**6.10**	**0.54**	**0.48**	**3.26**	**3.16**	**0.58**	**1.55**	**1.47**	**0.58**	**1.51**	**1.13**

Table-7 : Mean performance of forty genotypes of barley in environment-V .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant/ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	95.33	121.00	111.43	7.48	8.80	62.79	58.00	9.20	26.00	30.67	34.78	81.37	58.00
2	K-273	99.11	125.67	105.98	10.33	9.10	66.35	61.34	11.67	27.68	31.96	40.74	83.33	59.57
3	Manjula	97.66	124.34	113.04	8.55	10.13	65.44	55.67	11.19	26.20	25.11	47.60	81.00	56.17
4	K-678	96.97	124.00	105.30	8.28	9.55	68.00	63.33	12.27	26.03	26.67	48.40	76.19	58.60
5	Vijaya	90.55	121.34	106.99	7.07	9.39	55.33	50.00	10.70	26.05	24.56	47.29	81.52	56.97
6	Jagrati	92.66	121.33	121.18	9.30	9.40	56.45	49.00	9.41	25.67	21.22	50.04	81.09	57.57
7	Jyoti	101.98	129.00	109.77	8.73	8.30	59.67	55.33	9.95	25.50	21.33	50.79	84.44	54.90
8	PL—781	95.97	121.87	113.11	7.73	8.50	67.33	58.00	12.10	32.05	27.33	44.96	85.73	60.58
9	K-169	92.03	121.67	109.85	10.70	8.71	62.11	58.11	12.26	31.57	30.00	44.34	84.67	59.22
10	K-252	92.00	120.00	109.00	10.70	9.00	66.37	62.39	12.34	25.44	30.78	43.56	81.98	57.08
11	BH-851	98.67	127.00	106.11	8.90	8.94	63.11	53.78	12.77	26.00	29.55	44.98	80.00	59.39
12	K-370	87.76	122.00	115.44	8.70	9.16	69.22	57.77	11.70	31.66	24.66	48.43	84.31	60.05
13	K-729	96.05	126.80	110.17	8.86	8.89	73.33	63.00	10.52	32.00	25.61	44.66	86.00	59.98
14	BEU-73	97.75	130.05	116.80	7.97	8.74	67.55	63.66	12.22	28.89	25.11	52.09	85.01	61.75
15	K-341	92.67	122.00	105.56	7.23	8.72	62.78	60.56	12.03	30.96	28.56	44.63	83.00	58.33
16	K-603	96.10	122.10	108.78	10.23	9.00	69.55	61.66	9.26	31.00	26.68	36.19	84.19	58.8
17	K-683	100.74	129.05	110.24	11.30	9.50	79.44	64.26	11.44	26.43	31.18	38.51	82.00	57.90
18	K-792	97.00	122.66	108.44	10.37	9.30	65.22	57.33	12.53	30.55	28.67	45.33	81.23	58.88
19	K-784	95.34	123.40	105.34	11.67	9.19	71.05	62.00	12.42	31.78	26.99	48.70	81.98	60.00
20	K-409	96.00	127.67	111.00	9.03	9.44	65.66	53.67	10.65	25.96	27.33	40.29	82.00	60.80
21	K-1149	97.07	128.33	116.34	8.48	8.72	63.21	55.99	11.25	26.89	26.11	44.85	78.52	60.33
22	K-551	95.26	120.33	112.22	10.57	9.50	64.63	54.33	10.05	26.01	24.83	40.75	82.33	58.13

Table-7 Contd.....

Table-7 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	93.52	125.33	110.06	10.74	9.04	66.55	53.63	11.06	31.63	26.54	42.17	83.13	57.33
24	Lakhan	91.89	127.00	109.94	1032	9.55	64.00	53.86	12.88	26.50	26.22	51.88	79.97	58.75
25	K-804	93.65	119.83	117.17	1023	8.89	68.39	52.88	10.99	26.30	24.91	45.35	82.67	61.04
26	RD-2035	95.67	122.00	105.76	1097	9.40	65.66	61.22	12.26	30.59	28.87	45.62	81.67	57.11
27	K-318	101.33	128.67	108.89	9.28	9.14	75.89	61.24	11.83	26.55	27.55	43.07	83.67	58.67
28	K-1155	97.40	125.00	111.86	8.21	8.83	73.11	64.89	11.68	25.77	29.17	39.87	79.77	59.90
29	K-789	97.66	128.32	113.55	8.93	9.16	61.55	56.39	11.03	31.66	24.43	43.53	82.15	60.42
30	K-633	90.74	117.61	116.84	10.61	8.83	65.41	55.00	11.49	25.31	27.11	43.43	83.67	58.97
31	K-791	98.70	125.33	113.55	12.30	9.16	68.62	59.50	12.80	26.50	29.81	43.02	83.27	58.80
32	K-794	99.67	129.00	109.90	10.21	9.66	70.50	51.54	12.71	29.44	29.00	45.16	84.57	61.20
33	Amber	89.58	120.33	109.38	8.27	9.28	78.44	69.55	10.74	26.55	30.22	37.95	80.10	57.70
34	K-675	97.00	126.67	118.85	9.67	9.27	67.28	57.34	12.53	26.20	26.05	48.72	84.77	60.07
35	K-141	101.34	129.37	105.55	10.47	9.16	72.17	69.00	9.78	30.61	28.05	35.05	82.67	59.00
36	K-508	91.34	123.66	107.10	7.87	8.50	65.44	58.79	12.98	30.33	29.33	46.78	79.27	58.79
37	K-745	94.67	120.66	113.33	11.50	9.16	59.33	54.44	8.95	31.47	28.44	32.65	77.34	58.76
38	K-713	97.00	131.30	113.43	11.14	9.60	64.55	55.33	11.56	25.67	31.22	39.56	81.88	61.41
39	DL-65	96.33	125.66	109.03	10.29	9.33	60.33	51.78	12.14	30.55	28.55	45.38	81.98	60.70
40	DL-88	93.66	126.00	103.66	11.47	9.33	60.11	51.09	11.37	26.83	26.83	43.90	80.05	59.44
	Range	**87.76**	**117.61**	**105.30**	**7.07**	**8.30**	**55.33**	**49.00**	**9.20**	**25.31**	**21.22**	**34.78**	**76.19**	**54.90**
		101.98	**130.05**	**121.18**	**12.30**	**10.13**	**79.44**	**69.55**	**12.88**	**32.05**	**31.96**	**52.09**	**86.00**	**61.73**
	SED	**2.51**	**3.37**	**3.33**	**0.24**	**0.25**	**1.88**	**1.59**	**0.39**	**0.75**	**0.92**	**1.84**	**1.64**	**1.73**
	Grand Mean	**95.78**	**124.45**	**110.95**	**9.43**	**9.10**	**68.91**	**57.18**	**11.42**	**28.13**	**27.22**	**44.19**	**82.41**	**58.90**
	CD at 5 %	**4.99**	**6.71**	**6.63**	**0.48**	**0.50**	**3.74**	**3.16**	**0.78**	**1.49**	**1.83**	**3.66**	**3.26**	**3.44**

Table-8 : Mean performance of forty genotypes of barley in environment-VI .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	98.00	128.60	119.91	9.58	8.76	66.30	62.00	14.75	26.58	31.19	48.85	84.10	60.10
2	K-273	103.00	130.33	109.00	11.51	9.38	68.99	64.33	14.05	27.87	33.37	42.98	84.63	60.07
3	Manjula	101.66	129.67	117.11	9.43	10.37	66.11	57.83	14.27	26.51	27.66	52.00	82.07	62.00
4	K-678	100.33	129.67	110.45	8.70	9.50	66.89	64.55	13.21	27.66	27.67	46.97	83.58	63.49
5	Vijaya	96.00	123.99	108.55	8.84	9.50	57.66	53.72	13.42	26.91	28.55	46.86	83.17	60.90
6	Jagrati	99.17	125.42	123.17	10.97	9.38	57.00	53.87	12.13	26.44	24.99	51.39	85.54	60.94
7	Jyoti	105.38	132.00	111.44	9.55	9.33	66.90	62.84	12.47	26.17	25.97	51.60	80.03	62.73
8	PL—781	99.96	127.65	116.22	8.62	9.05	70.66	54.33	12.99	31.89	30.96	42.81	84.20	62.27
9	K-169	97.08	124.06	110.89	12.10	9.06	65.40	57.77	14.00	31.68	32.33	45.04	80.08	61.53
10	K-252	96.72	127.66	112.55	12.58	9.30	66.67	63.66	13.44	27.33	33.44	39.28	84.67	58.87
11	BH-851	102.00	132.36	110.00	11.26	9.28	67.33	63.33	14.40	29.00	34.23	43.12	80.94	60.30
12	K-370	93.66	126.67	118.89	10.61	9.37	64.33	62.00	12.26	32.05	26.66	46.53	86.20	64.40
13	K-729	99.71	128.67	113.89	8.61	9.80	67.45	63.44	11.78	32.63	28.00	42.21	83.90	60.95
14	BEU-73	100.67	132.30	118.22	9.56	10.28	68.44	65.66	12.36	29.89	28.71	41.28	85.61	60.97
15	K-341	95.67	126.67	110.16	9.27	8.91	73.00	61.89	12.96	31.77	31.87	39.74	83.53	59.08
16	K-603	100.33	126.67	115.50	12.66	9.23	67.88	63.44	11.35	31.33	28.00	39.30	83.00	61.50
17	K-683	98.99	133.30	116.03	13.22	9.90	60.65	56.42	12.60	26.67	33.33	38.66	80.87	59.57
18	K-792	99.91	128.67	110.68	12.30	9.61	63.77	59.66	13.58	31.58	31.33	45.16	83.40	61.50
19	K-784	96.00	126.67	107.20	13.50	9.53	70.33	66.22	13.94	32.00	28.00	53.00	81.20	60.80
20	K-409	99.71	130.00	115.90	12.32	9.50	68.00	57.55	10.66	26.00	29.67	35.69	81.13	61.47
21	K-1149	100.90	130.33	119.00	9.54	9.39	65.33	62.23	13.30	27.67	30.00	43.53	80.20	60.47
22	K-551	98.00	128.67	116.33	11.67	9.61	63.67	59.70	12.03	25.66	28.89	43.06	84.14	58.10

Table-8 Contd.....

Table-8 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	102.00	131.00	110.16	12.33	9.37	67.00	61.11	13.76	32.86	28.33	49.40	84.42	62.93
24	Lakhan	96.67	126.33	113.42	10.64	9.33	65.00	57.67	11.08	27.86	27.34	55.27	83.57	62.01
25	K-804	95.67	131.02	118.55	11.00	9.13	69.73	64.84	14.26	27.00	30.11	50.67	84.13	61.77
26	RD-2035	102.05	128.00	107.69	12.29	9.34	67.37	62.79	13.66	30.55	31.89	43.72	81.53	59.93
27	K-318	102.33	132.74	116.69	9.94	9.17	77.67	63.66	13.71	27.91	30.10	47.44	80.43	59.33
28	K-1155	96.67	131.00	115.84	9.05	9.17	76.01	65.57	13.42	26.27	33.23	42.65	78.37	63.33
29	K-789	102.00	132.65	116.03	10.82	9.66	65.00	57.11	11.65	31.55	27.00	44.61	84.43	59.57
30	K-633	92.00	124.33	117.94	11.95	9.51	68.00	60.55	13.37	27.66	28.00	48.85	81.90	61.16
31	K-791	102.00	133.34	116.83	12.53	9.97	68.00	54.24	13.59	27.67	32.67	44.10	82.47	60.10
32	K-794	101.34	129.00	113.54	11.14	9.53	72.67	60.22	14.29	29.33	31.67	46.99	82.20	61.97
33	Amber	93.00	127.33	116.32	9.47	9.42	79.67	72.03	14.85	26.22	32.00	34.89	78.87	60.00
34	K-675	100.51	130.96	119.43	11.50	9.53	79.67	61.46	12.98	26.00	28.57	45.90	82.43	61.30
35	K-141	104.67	131.33	112.95	13.02	9.17	74.43	73.33	12.59	31.78	31.03	42.59	80.40	61.19
36	K-508	93.67	124.67	106.83	8.77	8.41	70.67	59.22	12.00	30.44	30.20	39.74	81.80	58.07
37	K-745	98.33	124.67	112.17	12.22	8.73	65.55	61.11	10.43	30.33	27.00	38.63	80.58	60.74
38	K-713	100.67	131.00	113.70	12.78	9.43	57.55	53.78	11.70	25.67	32.00	36.56	79.40	58.79
39	DL-65	98.00	126.67	107.44	11.83	9.11	61.44	57.33	12.64	30.58	29.33	43.16	82.61	57.24
40	DL-88	94.33	124.00	103.50	13.00	9.00	70.00	63.89	13.00	31.00	26.00	50.00	79.67	59.71
	Range	**93.00**	**123.99**	**107.20**	**8.61**	**8.76**	**57.00**	**53.72**	**10.66**	**25.66**	**24.99**	**34.89**	**78.37**	**58.10**
		103.00	**133.34**	**123.17**	**13.50**	**10.37**	**79.67**	**73.33**	**14.85**	**32.86**	**34.23**	**55.27**	**86.20**	**64.40**
	SED	**3.01**	**3.48**	**3.35**	**0.30**	**0.26**	**2.16**	**1.85**	**0.34**	**0.76**	**0.88**	**1.25**	**1.67**	**1.00**
	Grand Mean	**99.25**	**129.14**	**114.47**	**10.91**	**9.45**	**68.08**	**61.45**	**13.09**	**28.79**	**29.90**	**45.01**	**82.60**	**61.04**
	CD at 5 %	**5.99**	**6.93**	**6.67**	**0.59**	**0.52**	**4.29**	**3.68**	**0.68**	**1.57**	**1.75**	**2.49**	**3.32**	**1.99**

Table-9 : Mean performance of forty genotypes of barley in environment-VII .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	90.66	121.02	113.71	6.73	8.89	56.61	55.32	8.56	24.00	26.62	33.96	80.43	58.10
2	K-273	94.67	124.67	105.00	9.40	8.89	65.33	59.75	10.63	26.66	29.83	36.18	81.93	56.50
3	Manjula	95.00	114.33	107.50	7.77	8.83	63.22	51.10	9.52	26.00	24.17	38.84	79.07	56.86
4	K-678	95.33	125.01	106.01	8.09	8.80	61.06	55.93	11.76	26.10	25.66	49.42	80.17	55.11
5	Vijaya	90.00	120.31	106.45	6.76	9.33	53.45	47.98	8.80	25.77	21.87	43.97	82.10	57.38
6	Jagrati	89.47	119.34	114.45	6.63	8.83	55.11	48.92	8.45	25.00	20.00	45.41	82.17	55.10
7	Jyoti	97.34	127.00	109.61	8.56	8.00	56.10	54.67	8.90	26.00	20.17	46.24	80.53	55.33
8	PL—781	92.00	121.34	108.99	7.78	7.79	66.84	54.00	11.27	31.29	26.44	44.01	79.33	57.00
9	K-169	89.00	121.34	107.67	8.94	8.33	57.67	52.27	11.42	29.22	28.50	39.69	80.07	56.87
10	K-252	90.33	119.50	110.17	8.70	7.22	64.11	58.28	10.97	25.33	27.55	40.33	75.90	55.10
11	BH-851	96.00	125.01	104.28	8.83	8.61	62.13	55.11	12.85	26.00	28.40	46.38	81.00	56.83
12	K-370	88.00	120.57	107.87	7.50	9.05	64.20	51.56	10.44	31.53	25.00	42.30	79.13	56.53
13	K-729	93.34	128.14	108.11	7.25	8.50	68.23	57.44	16.42	30.67	22.62	47.25	78.33	58.67
14	BEU-73	93.34	120.67	111.47	7.61	7.91	65.53	56.55	11.10	27.89	26.50	42.63	78.77	57.13
15	K-341	92.00	118.56	104.66	6.47	8.08	61.47	56.45	11.96	29.51	26.39	47.42	80.07	56.20
16	K-603	96.34	120.33	107.00	8.43	8.91	66.67	60.00	8.75	29.88	26.00	33.82	76.80	56.00
17	K-683	98.43	126.33	109.16	8.77	9.50	72.32	62.32	10.30	26.00	29.00	35.37	79.20	57.87
18	K-792	93.66	122.00	105.23	7.91	8.50	61.58	49.89	11.05	30.00	27.50	40.98	80.80	58.13
19	K-784	92.00	119.34	103.77	11.64	8.50	66.88	50.00	10.88	30.78	24.44	44.55	78.13	57.63
20	K-409	95.00	122.34	108.22	7.34	8.83	59.00	51.22	9.63	25.67	25.33	37.67	75.07	56.27
21	K-1149	93.00	123.33	115.50	7.99	8.47	58.33	52.11	10.34	26.33	24.66	41.79	82.30	58.00
22	K-551	92.00	119.89	108.40	9.23	8.74	63.44	51.02	8.45	25.67	22.00	37.02	77.83	58.07

Table-9 Contd.....

Table-9 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	92.00	118.67	104.98	10.11	8.69	59.80	50.11	9.67	30.77	25.91	38.24	77.93	56.60
24	Lakhan	90.34	120.64	106.86	7.63	8.67	61.58	52.33	11.39	25.96	25.35	43.69	78.53	56.37
25	K-804	92.67	118.16	113.83	8.34	9.14	67.33	49.64	10.60	26.67	30.00	35.35	78.10	58.69
26	RD-2035	92.33	123.78	103.89	10.37	9.16	57.66	55.55	10.78	31.01	27.29	42.03	85.77	54.90
27	K-318	100.67	129.00	109.61	7.88	8.96	63.44	59.91	9.05	26.10	27.84	25.63	79.43	55.10
28	K-1155	95.33	122.70	111.11	7.53	8.50	67.64	59.11	10.38	25.23	29.22	36.67	79.23	59.10
29	K-789	94.66	125.66	112.63	7.95	9.16	58.47	52.88	10.04	31.43	24.03	43.62	78.23	56.23
30	K-633	88.00	111.66	113.47	9.25	8.17	62.28	51.77	10.75	25.33	26.89	40.71	81.20	57.63
31	K-791	91.63	120.59	111.97	10.24	8.83	64.44	58.22	110.45	26.70	28.07	41.50	76.57	56.30
32	K-794	91.90	122.67	108.69	8.39	9.28	69.27	55.30	10.89	30.55	27.91	39.81	79.47	56.60
33	Amber	88.67	121.00	105.67	6.65	8.50	73.11	65.33	9.72	25.58	27.06	39.08	75.23	54.90
34	K-675	92.00	122.67	113.45	8.34	9.27	62.55	55.96	11.72	25.00	26.48	47.51	81.49	55.93
35	K-141	98.20	127.67	107.84	8.64	8.94	67.33	65.44	8.85	29.05	27.66	34.17	79.02	55.83
36	K-508	89.67	120.00	103.44	7.39	8.00	64.11	56.11	10.33	29.33	27.33	43.91	77.93	57.42
37	K-745	92.67	118.33	110.00	11.00	8.66	54.33	50.11	12.00	30.47	26.44	30.67	76.31	57.61
38	K-713	95.00	129.30	110.39	10.61	9.10	55.55	51.66	8.11	24.67	29.22	36.48	81.10	59.33
39	DL-65	94.33	123.90	105.55	9.83	8.83	60.33	48.78	10.66	29.55	26.55	42.07	80.62	58.91
40	DL-88	92.33	123.33	100.33	11.00	8.83	60.11	48.78	11.17	30.89	24.83	42.05	79.08	57.82
	Range	**88.00**	**111.66**	**103.77**	**6.47**	**7.22**	**53.45**	**47.98**	**8.45**	**24.00**	**20.00**	**33.82**	**75.07**	**54.90**
		100.67	**129.00**	**115.50**	**11.64**	**9.50**	**73.11**	**65.44**	**12.85**	**31.53**	**30.00**	**49.42**	**85.77**	**59.10**
	SED	**2.52**	**3.13**	**3.16**	**0.25**	**0.23**	**1.97**	**1.58**	**0.29**	**0.76**	**0.89**	**1.06**	**1.17**	**0.70**
	Grand Mean	**93.00**	**121.85**	**108.77**	**8.27**	**8.67**	**62.88**	**54.92**	**10.33**	**27.56**	**26.09**	**40.95**	**79.41**	**56.71**
	CD at 5 %	**5.01**	**6.23**	**6.29**	**0.50**	**0.46**	**3.92**	**3.14**	**0.58**	**1.51**	**1.77**	**2.11**	**2.33**	**1.39**

Table-10 : Mean performance of forty genotypes of barley in environment-VIII .

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	90.00	125.00	106.32	9.37	8.80	64.11	57.88	9.10	25.99	27.33	34.36	83.17	60.74
2	K-273	92.00	126.33	105.67	9.73	8.70	65.33	62.50	11.76	26.33	31.66	38.49	78.51	57.53
3	Manjula	96.34	128.33	113.13	8.59	10.10	56.00	51.66	9.91	26.66	25.88	40.52	83.07	60.41
4	K-678	92.68	127.00	105.56	7.63	8.44	53.22	50.22	12.85	26.33	26.79	50.67	80.58	58.50
5	Vijaya	91.66	121.26	108.74	7.37	9.03	47.67	43.98	9.31	26.09	24.80	41.59	78.28	58.11
6	Jagrati	93.34	122.00	115.72	10.64	9.16	53.79	52.77	10.08	26.25	21.99	50.28	82.84	58.67
7	Jyoti	97.34	131.00	106.17	8.66	8.50	57.89	51.44	10.05	27.67	22.17	47.49	79.36	61.27
8	PL—781	95.67	127.67	112.85	8.55	8.61	57.78	51.33	10.03	32.31	28.33	37.31	83.18	58.93
9	K-169	92.00	119.00	109.44	10.69	8.66	54.33	50.33	12.62	30.22	29.45	44.21	78.05	58.63
10	K-252	92.00	127.00	109.33	11.69	8.66	52.17	49.98	12.49	27.00	28.89	46.22	86.27	61.87
11	BH-851	97.00	128.61	106.36	8.93	8.88	59.99	56.67	12.98	27.55	30.80	42.79	80.58	59.83
12	K-370	86.33	122.00	111.70	9.81	9.16	61.16	54.00	11.41	32.10	25.13	45.09	81.39	60.58
13	K-729	94.00	126.65	117.11	8.12	9.40	54.11	51.77	11.26	31.00	25.13	49.67	84.35	60.77
14	BEU-73	97.00	130.67	113.33	8.50	9.61	62.06	57.61	11.27	28.22	28.11	43.59	82.74	59.72
15	K-341	91.34	123.66	107.10	7.87	8.50	65.44	58.79	12.98	30.33	29.33	46.78	79.27	58.79
16	K-603	94.67	120.66	113.33	11.50	9.16	59.33	54.44	8.95	31.47	28.44	32.65	77.34	58.76
17	K-683	97.00	131.30	113.43	11.14	9.60	64.55	55.33	11.56	25.67	31.22	39.56	81.88	61.41
18	K-792	96.33	125.66	109.03	10.29	9.33	60.33	51.78	12.14	30.55	28.55	45.38	81.98	60.70
19	K-784	93.66	126.00	103.66	11.47	9.33	60.11	51.09	11.37	26.83	26.83	43.90	80.05	59.44
20	K-409	94.33	129.67	114.00	9.43	9.39	53.17	43.99	10.08	29.22	29.22	35.64	80.01	58.52
21	K-1149	96.00	130.00	116.55	7.49	8.50	54.55	50.22	11.09	26.44	26.44	43.10	81.46	61.00
22	K-551	92.00	125.00	112.89	9.69	9.39	61.99	54.72	9 48	23.99	23.99	40.68	80.60	60.10

Table-10 Contd.....

Table-10 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	95.66	128.00	103.88	10.18	8.61	66.89	52.33	11.52	28.00	28.00	42.80	81.53	58.17
24	Lakhan	91.66	123.33	110.11	10.77	8.72	62.33	54.83	11.51	28.78	28.78	42.70	83.00	58.97
25	K-804	91.34	129.67	114.17	10.40	9.11	68.33	52.66	11.37	31.55	31.55	38.90	84.97	60.93
26	RD-2035	96.73	126.67	106.11	10.78	8.80	60.33	59.10	11.29	28.05	28.05	43.53	83.07	61.23
27	K-318	98.67	130.33	110.24	9.43	9.11	72.68	62.56	10.02	26.44	26.44	38.55	78.44	59.10
28	K-1155	90.67	126.67	111.89	8.46	9.17	71.33	62.44	11.25	29.65	29.65	35.68	81.47	61.20
29	K-789	95.00	130.67	116.75	10.45	8.78	60.55	54.33	11.27	25.00	25.00	42.54	79.38	59.57
30	K-633	86.33	121.00	114.26	10.59	9.50	61.11	53.00	11.17	27.17	27.17	41.24	79.87	60.37
31	K-791	98.34	130.68	113.44	12.35	9.68	60.77	56.77	12.24	29.33	29.33	42.88	82.75	58.93
32	K-794	97.00	127.33	111.57	9.70	9.13	60.97	56.66	11.77	29.22	29.22	42.39	83.80	60.00
33	Amber	87.67	123.05	109.34	9.13	8.72	66.39	59.12	10.38	29.21	29.21	38.00	78.85	59.47
34	K-675	97.00	127.00	116.11	10.43	8.39	65.87	59.45	12.76	27.09	27.09	51.49	78.67	57.50
35	K-141	99.35	129.67	106.66	11.70	8.94	70.00	65.00	9.63	30.72	30.72	30.49	78.33	59.27
36	K-508	90.00	115.33	100.33	6.00	7.58	58.47	54.78	11.03	28.51	24.39	45.22	79.02	55.34
37	K-745	94.67	118.00	103.67	8.00	8.41	64.00	58.00	7.84	28.55	24.80	31.61	75.66	52.72
38	K-713	96.33	124.33	105.83	8.66	9.00	70.66	60.32	9.37	24.00	27.00	37.70	78.07	56.67
39	DL-65	92.33	120.00	101.66	7.46	8.00	58.91	47.89	10.11	28.00	25.50	39.65	79.62	56.79
40	DL-88	90.33	116.61	100.44	11.11	8.00	64.55	46.67	9.91	29.11	23.11	42.88	76.81	55.76
	Range	**86.33**	**119.00**	**103.66**	**7.37**	**8.39**	**47.67**	**43.98**	**8.95**	**23.99**	**21.99**	**30.49**	**77.34**	**57.50**
		99.35	**131.30**	**117.11**	**12.35**	**10.10**	**72.68**	**65.00**	**12.98**	**32.31**	**31.66**	**51.49**	**86.27**	**61.87**
	SED	**2.78**	**3.48**	**3.43**	**0.28**	**0.25**	**1.65**	**1.72**	**0.30**	**0.80**	**0.84**	**1.01**	**1.00**	**0.59**
	Grand Mean	**93.95**	**126.53**	**110.74**	**9.74**	**9.04**	**58.81**	**57.56**	**11.11**	**28.53**	**27.73**	**42.03**	**81.11**	**60.22**
	CD at 5 %	**5.53**	**6.93**	**6.83**	**0.56**	**0.42**	**3.28**	**3.42**	**0.60**	**1.59**	**1.67**	**2.01**	**1.99**	**1.17**

Table-11 : Mean performance of forty genotypes of barley in pooled analysis.

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant/ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
1	RD-2684	92.75	122.87	111.85	8.09	8.61	58.63	57.22	10.02	25.06	27.96	36.70	82.41	58.69
2	K-273	95.89	125.50	104.91	10.02	8.77	62.67	60.89	11.63	26.59	30.84	38.50	80.67	57.96
3	Manjula	96.37	122.92	111.20	8.39	9.57	61.61	53.44	1079	25.84	24.83	43.86	81.06	58.35
4	K-678	94.91	122.29	105.22	7.99	9.02	61.17	59.52	12.05	26.19	25.83	47.62	81.70	58.46
5	Vijaya	90.90	120.41	106.66	7.31	9.06	51.74	49.63	10.09	25.68	23.67	43.81	80.04	57.84
6	Jagrati	92.33	120.80	117.02	9.17	9.03	54.09	49.89	9.64	25.24	20.86	48.10	83.88	57.66
7	Jyoti	99.80	128.83	107.53	8.66	8.24	58.74	55.95	9.93	25.81	21.38	47.82	79.84	58.56
8	PL—781	91.84	123.36	111.18	7.97	8.24	64.24	54.79	11.14	31.26	27.35	41.33	81.62	59.21
9	K-169	97.71	120.13	107.76	10.40	8.46	58.68	54.45	12.10	30.07	29.11	42.28	79.42	58.51
10	K-252	88.18	122.33	108.18	1070	8.32	61.16	60.83	11.85	25.53	29.25	41.27	82.26	57.67
11	BH-851	95.01	127.46	104.82	9.27	8.70	66.39	60.14	12.80	26.39	29.91	43.45	81.05	58.60
12	K-370	96.43	121.61	112.00	8.94	8.95	63.11	54.66	10.98	30.95	24.53	44.97	83.13	64.87
13	K-729	92.09	126.20	110.49	7.44	8.90	64.49	59.75	10.57	31.08	24.38	44.70	82.92	59.59
14	BEU-73	96.01	127.51	113.41	8.19	8.88	63.73	59.67	11.26	28.22	26.23	43.79	81.82	59.46
15	K-341	98.27	121.38	105.12	7.50	8.30	64.59	58.25	12.01	30.09	38.12	43.60	80.21	57.17
16	K-603	95.82	121.35	109.53	10.49	8.82	63.57	60.93	9.13	30.38	26.69	34.47	78.98	58.22
17	K-683	93.33	129.12	110.72	10.93	9.38	66.11	63.05	11.03	25.57	30.27	37.00	79.81	58.45
18	K-792	95.30	123.79	106.68	9.99	8.94	61.73	53.46	11.86	30.05	28.05	43.09	81.69	58.75
19	K-784	95.91	122.63	103.24	11.83	8.88	66.39	56.04	11.69	31.03	25.61	46.47	80.30	58.83
20	K-409	93.32	126.34	110.99	9.31	9.04	57.83	52.66	9.80	25.32	27.05	36.50	79.52	58.61
21	K-1149	94.94	126.38	114.76	8.11	8.52	58.52	54.96	10.79	26.50	25.93	42.28	79.67	59.38
22	K-551	91.49	122.32	111.02	10.08	9.06	62.43	53.72	9.63	25.37	24.09	39.58	80.56	58.07

Table-11 Contd.....

Table-11 Contd.....

Sl. No.	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant/ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
23	K-790	92.42	124.75	105.41	10.62	8.68	63.73	53.05	11.10	31.11	26.40	42.40	81.13	58.22
24	Lakhan	95.68	123.12	108.64	9.61	8.90	61.77	53.75	12.18	26.28	25.89	47.69	80.79	58.50
25	K-804	99.96	123.58	114.25	9.76	8.82	67.10	53.76	11.34	26.21	28.02	41.54	82.80	60.02
26	RD-2035	93.67	124.06	104.33	10.87	8.97	61.29	58.54	11.56	29.89	27.88	42.63	82.66	57.77
27	K-318	96.54	129.01	109.90	8.91	8.85	71.60	60.76	10.69	26.49	27.04	40.06	80.01	57.58
28	K-1155	88.34	125.21	111.18	8.06	8.67	70.60	61.69	11.21	25.38	29.70	37.68	79.15	60.31
29	K-789	96.79	128.16	112.64	9.23	8.94	59.85	53.93	10.47	31.19	24.38	42.81	80.55	58.43
30	K-633	96.57	117.28	114.14	10.38	8.75	62.83	54.00	11.23	25.85	26.46	42.71	81.02	58.91
31	K-791	88.74	126.12	112.41	11.62	9.16	63.24	57.22	12.07	26.38	29.30	41.73	81.18	58.07
32	K-794	95.52	125.88	109.22	9.65	9.12	66.86	56.31	11.95	29.25	28.50	41.59	81.71	59.38
33	Amber	96.25	121.71	108.54	8.15	8.73	71.19	67.21	10.02	25.78	28.41	36.34	77.73	57.63
34	K-675	97.18	125.88	114.95	9.75	8.86	67.26	57.47	12.03	25.39	25.92	47.53	81.03	58.23
35	K-141	100.03	128.30	106.21	10.65	8.80	68.42	61.23	9.74	30.33	28.41	34.63	79.95	58.31
36	K-508	91.67	120.00	102.89	6.94	8.19	60.78	58.33	11.11	29.89	26.89	41.32	77.00	54.10
37	K-745	95.00	120.00	105.78	9.89	8.50	66.22	59.33	8.33	30.00	25.35	32.86	78.03	57.68
38	K-713	99.00	128.33	106.94	10.94	9.03	77.11	62.33	10.55	25.43	29.17	36.17	76.00	57.04
39	DL-65	95.00	121.00	105.44	9.89	8.33	62.22	55.00	11.61	29.55	27.00	43.00	78.25	57.84
40	DL-88	92.67	121.67	101.67	11.28	8.69	68.05	59.67	11.50	30.78	24.67	46.70	80.48	59.38
	Range	**88.18**	**117.28**	**103.24**	**1.31**	**8.24**	**51.74**	**49.63**	**9.13**	**25.06**	**20.86**	**34.47**	**77.73**	**57.17**
		100.03	**129.12**	**117.02**	**11.83**	**9.57**	**71.60**	**67.21**	**12.80**	**31.26**	**39.12**	**48.10**	**83.88**	**64.87**
	SED	**1.31**	**1.72**	**1.57**	**0.13**	**0.12**	**0.90**	**0.80**	**0.15**	**0.38**	**0.39**	**0.55**	**0.46**	**0.35**
	Grand Mean	**94.53**	**124.33**	**109.58**	**9.37**	**8.82**	**62.89**	**57.15**	**11.03**	**27.64**	**26.80**	**42.04**	**80.92**	**58.69**
	CD at 5 %	**2.53**	**3.42**	**3.12**	**0.25**	**0.24**	**1.79**	**1.59**	**0.298**	**0.76**	**0.78**	**1.09**	**0.92**	**0.69**

Table-12 : Phenotypic coefficient of variation (PCV) for 13 characters of eight environment and pooled analysis in barley.

S. No.	Characters	I	II	III	IV	V	VI	VII	VIII	Pooled
1	Days to flowering	4.81	4.46	4.38	4.65	4.50	4.42	4.25	4.64	4.64
2	Days to maturity	4.09	3.58	4.34	4.06	3.86	3.41	3.95	3.84	4.04
3	Plant height (cm)	4.72	4.73	4.49	4.48	4.81	4.53	4.22	4.70	4.71
4	No. of tillers per plant	15.50	14.47	15.19	14.03	15.07	13.92	14.35	13.25	13.10
5	Ear length (cm)	4.71	4.73	6.61	5.56	4.78	4.56	6.21	5.31	4.43
6	No. of spikelets per plant	8.64	8.52	8.74	11.14	8.44	8.42	8.10	11.08	7.21
7	No. of seeds per plant	9.08	8.20	9.00	9.12	8.62	7.98	8.66	8.58	8.01
8	Grain yield per plant (g)	10.23	9.08	12.06	11.70	10.01	8.47	11.27	10.74	8.54
9	1000-grain weight (g)	9.65	9.11	9.21	8.83	9.28	8.79	9.06	8.28	9.00
10	Biological yield per plant (g)	10.96	9.26	10.80	10.12	10.05	8.62	10.21	9.26	9.30
11	Harvest index (%)	11.46	10.76	11.31	11.67	10.93	11.02	10.98	12.09	8.90
12	Malt (%)	2.98	2.95	3.07	3.05	3.79	3.28	3.20	3.01	1.77
13	Starch (%)	2.92	2.59	2.18	6.40	3.91	2.79	2.41	6.25	1.98

Table-13 : Genotypic coefficient of variation (GCV) for 13 characters of eight environments and pooled analysis in barley.

S. No.	Characters	I	II	III	IV	V	VI	VII	VIII	Pooled
1	Days to flowering	3.49	2.72	2.55	3.01	3.15	2.39	2.65	2.89	3.14
2	Days to maturity	2.09	0.45	2.50	1.97	1.98	0.84	2.38	1.84	2.19
3	Plant height (cm)	3.14	3.14	2.75	2.73	3.09	2.76	2.25	2.76	3.12
4	No. of tillers per plant	15.15	14.02	14.76	13.56	14.74	13.49	13.84	13.27	12.64
5	Ear length (cm)	3.09	3.11	5.57	4.27	3.31	2.98	5.22	4.05	2.83
6	No. of spikelets per plant	7.92	7.76	7.98	10.56	7.69	7.46	7.13	10.54	6.29
7	No. of seeds per plant	8.36	7.40	8.26	8.40	7.96	7.09	7.91	7.76	7.22
8	Grain yield per plant (g)	9.61	8.37	11.52	11.14	9.07	7.85	10.70	10.21	7.80
9	1000-grain weight (g)	8.98	8.39	8.49	8.09	8.68	8.11	8.39	7.52	8.33
10	Biological yield per plant (g)	10.31	8.55	10.19	9.47	9.15	7.82	9.30	8.48	8.58
11	Harvest index (%)	10.28	10.41	11.25	11.64	9.66	10.48	10.51	11.72	8.30
12	Malt (%)	2.76	2.72	2.89	2.82	2.94	2.15	2.63	2.59	1.07
13	Starch (%)	2.64	2.32	1.84	6.29	1.50	1.92	1.87	6.13	1.32

The PVC ranged from 3.41 in environment-VI to 4.34 in empowerment-III, while the values of GCV ranged from 0.45 in environment-II to 2.66 in environment-III. In pooled analysis, the GCV recorded as 2.19 and PCV 4.04. The values of PCV were higher as compared to GCV showing the influence of the environment on the character.

3. Plant height (cm)

The minimum plant height (100.28) was observed In genotype BH-851 in environment-III, while maximum plant height (123.17) was recorded for genotype Jagrati in environment-VI. In pooled analysis, K-784 showed minimum plant height (103.24 cm) while maximum plant height (117.02 cm) was recorded for Jagrati. The general mean was 109.58 ± 3.124 which indicated that the plant height had the wide range of variation and some accessions showed consistent performance across the environments.

The maximum PCV (4.81) in environment-V and GCV (3.14) was observed in environment-I and II while minimum PCV (4.22) and GCV (2.25) was recorded in environment-VII. In pooled analysis, the values of PCV (4.71) and GCV (3.12) are comparable means that trait was less affected by the environment.

4. Number of tillers per plant

The maximum number of tillers per plant was produced by the genotype K-784 (13.50) and minimum (6.00) by K-341 in environment-VI and III, respectively. Pooled analysis of all the eight environments over two years indicated that the maximum tiller number per plant (11.83) was produced by the genotype K-784 and minimum (7.31) produced by the genotype

Vijaya. The genotype K-791 (11.62), K-252 (10.70) and K-141 (10.65) were also identified as high tiller producing genotypes. The grand mean for this trait (9.37 ± 0.258), indicated the existence of variability for this trait and some accessions had better performance over the wider range of environments.

The number of tillers per plant had higher values for both PCV (15.50) and GCV (15.15) in environment-I and lower values (13.75 and 13.27) in environment-VIII. In pooled analysis, the values of PCV (13.10) and GCV (12.64) are almost in same range indicating the variability due to genotype and thus the selection can be reliable for this trait.

5. Ear length (cm)

The genotype Manjula produced longest ear (10.37 cm) in environment-VI and genotype K-252 produced shortest ear (6.72 cm) in environment-III. On the basis of pooled analysis, genotype Manjula was found for longest ear length (9.57 cm) and K-273 produced shortest ear (8.24 cm). The general mean recorded for this trait was 8.82 ± 0.238.

Across the environments, it was seen that the ear length in environment-III had maximum PCV (6.61) and GCV (5.57) and minimum value of PCV (4.70) in environment-I and GCV (2.98) in environment-VI. In pooled analysis it showed differences in values of PCV (4 43) and GCV (2.83).

6. Number of spikelets per ear

The maximum number of spikelets per ear (79.67) was produced by genotype Amber and K-675 in environment-VI and minimum (43.17) by

K-409 in environment-IV. However, in pooled analysis the maximum number of spikelets per ear (71.60) was produced by the genotype K-318 followed by Amber (71.19), K-1155 (70.60) and K-141 (68.42) and the minimum number of spikelets per ear was produced by the genotype Vijaya (51.74) with the grand mean 62.89 ± 1.791 which showed the sufficient variability for this trait.

The value of phenotypic coefficient of variation is higher (11.08) in environment-VIII and lower (8.74) in environment-III, while GCV was higher (10.56) in environment-IV and lower (7.13) in environment-VII. In pooled analysis, number of spikelets per ear showed higher value of PCV (7.21) than GCV (6.29) indicating the role of environment in expression of this trait.

7. Number of seeds per spike

The number of seeds per spike ranged from 40.11 (Vijaya) in environment-IV to 73.30 (K-141) in environment-VI. The character showed wide spectrum of variability across the environments. In pooled analysis the genotype Amber produced maximum number of seeds per spike (67.21) followed by K-783 (63.05), K-1155 (6169). While genotype Vijaya produced minimum number of seeds per spike (49.63). The grand mean recorded for this trait was 57.15 ± 1.592.

High value of PCV (9.12) and GCV (8.40) was recorded for number of seeds per spike in environment-IV, while low value of PCV (798) and GCV (7.09) in environment-VI. In pooled analysis, PCV (8.01) and GCV (7.22) showed consistent performance across the environment.

8. Grain yield per plant (g)

The highest grain yield per plant was recorded for genotype Amber (14.85g) in environment lowest for genotype Jagrati and K-551, (1.55 g) in environment-III. On the basis of pooled analysis the mean value for grain yield per plant was observed highest in BH-851 (12.80g) followed by Lakhan (12.18g), K-791 (12.07g), K-678 (12.05g) and K-675 (12.03g) whereas the genotype K-603 (9.13g) recorded lowest grain yield per plant, indicating the presence of ample genetic variability in experimental material for this trait and general mean was 11.03 ± 0.298.

Grain yield per plant had high value of PCV (11.70) and GCV (11.52) in environment-IV and III, respectively while, low value of PCV (8.47) and GCV (7.85) in environment-VI. The same trend of PCV (8.54) and GCV (7.80) was observed in pooled analysis indicating the role of genotype than environment.

9. 1000-grain weight (g)

1000-grain weight was maximum in genotype K-790 (32.86) ~~in~~ environment-VI and minimum for genotype RD-2684 (23.00) ~~in~~ environment-III. While in pooled analysis the highest 1000-grain weight was observed in genotype PL-781 (31.26) and lowest (25.06) for genotype RD-2684 with grand mean of 27.64 ± 0.756 represent the presence of high variability for this trait.

The higher values of PCV (965) and GCV (8.98) were observed for 1000-grain weight in environment-I and lower values of PCV (8.28) and GCV (7.52) were found in environment-VIII. Pooled analysis showed that

the 1000-grain weight performs consistently across the environments which means that it was less affected by the environment.

10. Biological yield per plant (g)

The highest biological yield per plant was observed for genotype BH-851 (34.23) in environment-VI and lowest biological yield for genotype Jagrati (1700) in environment-III. The data of all the environments over two years revealed that the maximum biological yield per plant was noticed in genotype K-341 (38.12) and minimum for Jagrati (20.86). These results indicate the presence of wide range of variability for this trait, while some genotypes showed their better performance across the environments. The general mean of this trait was 26.80 ± 0.776.

High values of PCV (10.90) and GCV (10.31) were observed in environment-I while the lower values of PCV (8.62) and GCV (7.82) were found in environment-VI. On the basis of pooled analysis biological yield per plant had the intermediate values of PCV (9.30) and GCV (8.58).

11. Harvest index (%)

The maximum harvest index (55.27) was found in genotype Lakhan and minimum in genotype K-141 (30.49) in environment-VI and IV, respectively. The pooled analysis showed the maximum harvest index (48.10) in genotype Jagrati and minimum (34.47) for genotype K-603 with grand mean 42.04 ± 1.094 showed presence of sufficient variability for this trait.

The maximum values of PCV (12.09) and GCV (11.72) were recorded in environment-VIII and minimum value of PCV (10.76) in

environment-II and GCV (9.66) in environment-V. Pooled analysis revealed that the harvest index had lower values of PCV (8.90) and GCV (8.30).

12. Malt percentage

Malt percentage was found high in K-252 (86.27) in environment-VIII and low in Amber (74.03) in environment-III. As per pooled analysis the genotype Jagrati (83.88) was found superior in malt quality followed by K-370 (83.13), K-729 (82.92), K-804 (82.80) and RD-2035 (82.68). The genotype Amber produce minimum malt percentage (77.73) which is below the mean ~~a e~~ 80.92 ± 0.915 indicating ~~that~~ the high order of variation present for this trait in the genotypes.

For malt percentage the highest values of PCV (3.79) and GCV (2.94) were found in environment-V while lowest values of PCV (2.95 and GCV (2.15) in environment-II and VI, respectively. Whereas, in pooled analysis the minimum differences in the values of PCV (1.77 and GCV (1.07) showed low effect of environment on this trait.

13. Starch percentage

Among all the environments, the highest percentage of starch was found in genotype K-370 (79.71) in environment-IV and lowest in genotype K-1155 (50.78) in environment-I. On the basis of pooled analysis, genotype K-370 (64.87) was found best for starch percentage followed by K-1155 (60.31) and K-804 (60.02). The minimum starch percentage was observed in genotype K-341 (57.17) ~~which was below to~~ general mean 58.69 ± 0.696.

It is clear from Table-12 and 13 that the higher values for PCV (6.40) and GCV (6.29) were observed in environment-IV and lower values

of PCV (2.18) in environment-III and GCV (1.50) in environment-V. However, in pooled analysis, starch percentage exhibited lower values of PCV (1.98) and GCV (1.32).

In general, the phenotypic coefficient of variability (PCV) were higher to the corresponding genotypic coefficient of variability (GCV) for all the traits (Table-12 and 13), showing the presence of environmental influences for these characters. The high estimates for both PCV and GCV were obtained for tiller number per plant, biological yield per plant. 1000 grain weight, harvest index, grain yield per plant, number of seeds per spike, and number of spikelets per ear indicating that the presence of ample genetic variability in the experimental material for these characters.

4.2 HERITABILITY ESTIMATES

Heritability and genetic advance are important selection parameters, because heritability helps the plant breeder in selection of elite genotype from genetically diverse population. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. In the present investigation, the results of estimates of heritability are presented in Table-14. The results indicated that in environment-IV highest heritability was recorded for the harvest index (99.40%), followed by starch percentage (96.60%) and grain yield per plant (90.70%). Among other environments, tiller number per plant (95.60%) in environment-V, number of spikelets per ear (90.40%) in environment-VIII, biological yield per plant (89.30%) in environment-I, malt percentage (88.30%) in environment-III, 1000-grain weight (87.40%) in environment-V and number of seeds per spike (85.20%) in environment-V also showed high heritability estimates. Whereas, moderate heritability

Table-14 : Heritability for 13 characters of eight environment and pooled analysis in barley.

S. No.	Characters	I	II	III	IV	V	VI	VII	VIII	Pooled
1	Days to flowering	52.70	37.20	34.00	41.90	49.00	29.20	38.80	38.90	45.80
2	Days to maturity	26.00	19.60	33.20	23.50	26.10	19.10	36.30	22.90	29.30
3	Plant height (cm)	44.40	44.10	37.40	37.00	41.30	37.10	28.50	34.50	44.00
4	No. of tillers per plant	95.50	94.00	94.40	93.40	95.60	93.80	93.10	93.10	93.10
5	Ear length (cm)	43.00	43.40	71.10	58.90	48.10	42.70	70.60	58.30	40.90
6	No. of spikelets per plant ear	84.10	82.90	83.40	89.70	83.20	78.50	77.50	90.40	76.20
7	No. of seeds per plant Spike	84.80	81.50	84.30	84.80	85.20	78.90	83.40	81.70	81.20
8	Grain yield per plant (g)	88.30	84.90	91.20	90.70	82.20	85.80	90.10	90.40	83.40
9	1000-grain weight (g)	86.60	84.80	85.10	83.80	87.40	85.20	85.80	82.50	85.70
10	Biological yield per plant (g)	89.30	85.30	89.10	87.60	82.90	82.20	83.00	83.90	85.10
11	Harvest index (%)	80.40	93.10	98.90	99.40	78.20	90.30	91.60	94.00	87.00
12	Malt (%)	85.30	85.80	88.30	85.40	60.10	42.90	67.60	74.40	73.72
13	Starch (%)	82.00	80.10	71.30	96.60	14.70	47.40	60.10	96.30	68.56

estimates were observed for ear length (58.30) in environment-VIII, days to flowering (52.70%) and plant height (44.40%) in environment-I. The low heritability estimates were recorded for days to maturity (36.30) in environment-VIII. Pooled analysis indicated the higher heritability estimates for tiller number per plant (93.30%), harvest index (87.00%), 1000-grain weight (85.70%), biological yield per plant (85.10%), grain yield per plant (83.40%), number of seeds per spike (81.20%), number of spikelets per ear (76.20%), malt percentage (72.72%) and starch percentage (68.56%). Similarly moderate heritability estimates were recorded for days to flowering (45.80%), plant height (44.00%) and ear length (40.90%). However, only one character *i.e.*, days to maturity had low heritability estimates (29.30%)

4.3 GENETIC ADVANCE

The high broad sense heritability alone is of little use in predicting the breeding values of any trait (Jhonson *et al.,* 1955). It was suggested (Panse, 1957) that if heritability were large a function of additive gene effects, it would be associated with high genetic advance because heritability in broad sense alone is not sufficient to indicate the fixable portion of variability present in any population.

The highest genetic advance was observed for number of spikelets per ear (12.14) in environment-VIII, while harvest index (9.84) in environment-VIII, number of seeds per spike (9.01) in environment-I, starch percentage (7.54) in environment-IV and biological yield per plant (5.12) in environment-I, showed moderate estimates of genetic advance. Other characters like days to flowering (4.90), plant height (4.66) in environment-I, 1000-grain weight (4.71) in environment-V, malt percentage (4.37) in environment-III, days to maturity (3.60) in environment-VII, tiller number per

Table-15 : Genetic advance for 13 characters of eight environment and pooled analysis in barley.

S. No.	Characters	I	II	III	IV	V	VI	VII	VIII	Pooled	GA as % of mean
1	Days to flowering	4.90	3.32	2.79	3.70	4.35	2.64	3.16	3.49	4.14	4.37
2	Days to maturity	2.69	0.15	3.54	2.44	2.59	0.56	3.60	2.29	3.04	2.44
3	Plant height (cm)	4.66	4.78	3.65	3.67	4.54	3.97	2.60	3.69	4.67	4.26
4	No. of tillers per plant	2.76	2.93	2.32	2.49	2.80	2.94	2.28	2.57	2.63	28.06
5	Ear length (cm)	0.36	0.38	0.79	0.58	0.43	0.38	0.78	0.58	0.33	3.74
6	No. of spikelets per ~~plant~~ ear	9.61	9.52	9.06	11.66	9.67	9.26	8.13	12.14	7.11	11.30
7	No. of seeds per ~~plant~~ spike	9.01	8.19	8.24	8.75	8.92	8.03	8.17	8.31	7.66	13.40
8	Grain yield per plant (g)	1.96	1.93	2.13	2.23	1.93	1.96	2.16	2.22	1.62	14.68
9	1000-grain weight (g)	4.64	4.41	4.24	4.14	4.71	4.44	4.41	4.01	4.39	15.88
10	Biological yield per plant (g)	5.12	4.59	4.77	4.70	4.67	4.37	4.56	4.44	4.37	16.30
11	Harvest index (%)	7.90	8.98	9.07	9.52	7.78	9.24	8.49	9.84	6.70	15.93
12	Malt (%)	4.19	4.24	4.37	4.30	3.95	2.40	3.53	3.74	4.16	5.14
13	Starch (%)	2.85	2.57	1.78	7.54	0.70	1.66	1.69	7.46	3.38	5.75

plant (2.94) in environment-VI, grain yield per plant ~~i.e.,~~ (2.23) in environment-IV and ear length (0.79) in environment-III had low genetic advance. On the basis of pooled analysis ~~it was observed that~~ the high heritability coupled with high genetic advance was observed for number of seeds per spike, number of spikelets per ear and harvest index. However, plant height (4.67), 1000-grain weight (4.39), biological yield per plant (4.37), malt percentage (4.16) and ~~character~~ days to flowering had moderate genetic advance (4.14). While low genetic advance was observed for starch percentage, days to maturity and tiller number per plant. The genetic advance as percentage of mean ~~was also calculated and it is clear from~~ presented in Table-15 revealed that the character number of tillers per plant (28.06) registered ~~was on top which was low in pooled analysis whereas characters~~ the highest genetic advance as percentage of mean followed by biological yield per plant (16.30), Harvest index (15.93), 1000-grain weight (15.83), grain yield per plant (14.68), number of seeds per spike (132.40) and number of spikelets per ear (11.30) ~~showed high genetic advance as percentage of mean~~ with high heritability estimates. Moderate heritability with low genetic advance was observed for plant height, days to flowering, ear length, malt and starch percentage.

4.4 CORRELATION STUDIES

~~In present investigation,~~ The results of correlation coefficients for thirteen traits are presented in Table-16 to 24. In general, the magnitude of genotypic correlation coefficients was higher than the phenotypic correlation coefficients.

Not necessary, only phenotypic correlation coefficients alone presented

1. Days to 50 % flowering

Days to 50 % flowering showed highly significant positive correlation with number of seeds per spike (0.454 and 0.443) in environment-VII and VIII ~~respectively;~~

Table-16 : Phenotypic correlation coefficient of 13 characters in barley at environment -I.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant/ear	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	2.392	-0.041	0.064	-0.030	0.148	0.240	-0.016	-.0097	0.117	-.0122	-0.044	0.163
Days to maturity		-	-0.406*	0.012	-0.026	0.128	0.130	0.111	0.058	-0.047	0.161	-0.045	0.302
Plant height (cm)			-	-0.168	-0.028	-0.127	-0.286	-.0216	-0.312	-0.247	0.530**	0.106	0.175
No. of tillers/plant				-	0.201	0.162	0.028	0.223	0.032	0.264	-0.070	0.019	0.036
Ear length (cm)					-	-0.038	-0.033	0.379*	-0.207	0.123	-0.063	-0.031	-0.210
No. of spikelets/plant/ear						-	0.607**	0.346*	0.151	0.408*	-0.276	0.180	0.169
No. of seeds/plant/spike							-	0.126	0.151	0.597**	-0.456**	0.032	0.015
Grain yield/plant (g)								-	0.085	0.406*	0.469**	-0.099	0.173
1000-grain weight (g)									-	-0.002	0.045	0.074	0.164
Biological yield/plant (g)										-	-0.611**	-0.104	-0.032
Harvest index (%)											-	0.008	0.181
Malt (%)												-	0.143
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-17 : Phenotypic correlation coefficient of 13 characters in barley at environment -II.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.046	0.072	0.066	0.265	-0.019	0.213	-.0056	0.186	-0.034	-0.027	-.0082	-0.018
Days to maturity		-	-0.279	0.084	-0.173	0.251	0.031	0.117	-0.246	0.296	-0.160	0.009	-0.027
Plant height (cm)			-	-0.202	0.382*	-0.122	-0.053	-0.339*	-0.160	-0.348*	0.022	0.183	0.024
No. of tillers/plant				-	-0.023	-0.007	0.043	0.386*	0.100	0.180	-0.076	-0.055	-0.166
Ear length (cm)					-	-0.434**	0.090	-0.326*	0.032	-0.254	0.034	0.220	-0.033
No. of spikelets/plant						-	0.373*	0.389*	0.002	0.280	-0.175	-0.366*	-0.102
No. of seeds/plant							-	-0.171	0.101	0.246	-0.352*	-0.352*	0.050
Grain yield/plant (g)								-	-0.103	0.326*	0.564**	0.039	0.050
1000-grain weight (g)									-	-0.184	0.048	0.107	-0.280
Biological yield/plant (g)										-	-0.593**	-0.246	0.290
Harvest index (%)											-	0.231	0.001
Malt (%)												-	-
Starch (%)													

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-18 : Phenotypic correlation coefficient of 13 characters in barley at environment -III.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.096	0.395*	-0.059	0.378*	-0.079	0.443**	-.0282	0.206	-0.095	-0.205	-0.049	-0.001
Days to maturity		-	-0.491**	0.110	-0.142	0.229	0.130	0.125	-0.117	0.187	-0.028	0.034	-0.095
Plant height (cm)			-	-0.327*	0.350*	-0.351*	0.067	-0.326*	-0.079	-0.277	-0.064	0.051	0.196
No. of tillers/plant				-	-0.062	-0.190	-0.085	0.359*	0.127	0.331**	0.058	0.035	-0.150
Ear length (cm)					-	-0.104	0.106	-0.289	0.097	-0.111	-0.191	0.247	0.004
No. of spikelets/plant						-	0.444**	0.393*	0.080	0.543**	-0.318	-0.464**	0.094
No. of seeds/plant							-	-0.044	0.060	0.293	-0.320	-0.225	-0.135
Grain yield/plant (g)								-	0.136	0.506**	0.541**	0.048	-0.003
1000-grain weight (g)									-	-0.042	0.171	0.042	-0.053
Biological yield/plant (g)										-	-0.448**	-0.220	0.132
Harvest index (%)											-	0.273	-0.127
Malt (%)												-	-0.059
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-19 : Phenotypic correlation coefficient of 13 characters in barley at environment -IV.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.075	0.369*	-0.067	0.334*	-0.075	0.343*	-0.133	0.324	-0.102	-0.032	-0.042	-0.272
Days to maturity		-	-0.465**	0.091	-0.279	0.320	-0.092	0.206	-0.324	0.336*	-0.081	0.186	-0.117
Plant height (cm)			-	-0.084	0.562**	-0.189	0.156	-0.236	0.122	-0.286	0.030	0.191	0.140
No. of tillers/plant				-	-0.015	0.201	0.053	0.358*	0.062	0.346*	-0.139	0.095	-0.009
Ear length (cm)					-	-0.208	0.116	-0.234	0.039	-0.140	-0.113	0.220	0.091
No. of spikelets/plant						-	0.025	0.177	0.138	0.274	-0.067	0.029	0.047
No. of seeds/plant							-	-0.095	-0.048	0.326*	-0.367*	-0.086	-0.120
Grain yield/plant (g)								-	-0.157	0.440**	0.595**	0.203	0.016
1000-grain weight (g)									-	-0.093	0.021	-0.089	0.151
Biological yield/plant (g)										-	-0.456**	0.112	-0.185
Harvest index (%)											-	0.104	0.190
Malt (%)												-	0.149
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-20 : Phenotypic correlation coefficient of 13 characters in barley at environment -V.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	0.266	0.070	0.086	-0.086	0.188	0.231	0.017	-0.103	0.081	-0.127	-0.100	0.030
Days to maturity		-	-0.336*	0.015	-0.051	0.133	0.126	0.095	0.053	-0.062	0.113	-0.120	0.127
Plant height (cm)			-	-0.099	-0.005	-0.099	-0.297	-0.099	-0.196	-0.331*	0.143	0.106	0.138
No. of tillers/plant				-	0.157	0.163	-0.005	0.239	0.017	0.251	-0.103	-0.143	-0.013
Ear length (cm)					-	-0.032	-0.086	0.344*	-0.176	0.037	-0.031	-0.005	-0.177
No. of spikelets/plant						-	0.601**	0.334*	0.144	0.344*	-0.281	-0.045	0.161
No. of seeds/plant							-	0.399*	0.161	0.535**	-0.423**	-0.055	0.118
Grain yield/plant (g)								-	0.391*	0.342*	0.447**	-0.048	0.178
1000-grain weight (g)									-	-0.022	0.019	0.179	0.224
Biological yield/plant (g)										-	-0.568**	-0.142	0.061
Harvest index (%)											-	0.194	-0.008
Malt (%)												-	0.053
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-21 : Phenotypic correlation coefficient of 13 characters in barley at environment -VI.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.109	0.059	0.007	0.244	-0.104	0.118	-0.076	0.162	-0.109	0.017	-0.014	0.034
Days to maturity		-	-0.251	0.086	-0.113	0.301	0.046	0.109	-0.256	0.314	-0.109	-0.088	-0.062
Plant height (cm)			-	-0.225	0.284	-0.068	-0.010	-0.328*	-0.144	-0.339*	0.020	0.122	0.015
No. of tillers/plant				-	-0.026	-0.027	0.056	0.378*	0.116	0.221	-0.064	-0.055	-0.165
Ear length (cm)					-	-0.362*	-0.036	-0.265	-0.041	-0.321	0.007	0.101	-0.085
No. of spikelets/plant						-	0.359*	0.376*	-0.045	0.336*	-0.201	-0.317	0.025
No. of seeds/plant							-	-0.173	0.114	0.197	-0.309	-0.202	-0.080
Grain yield/plant (g)								-	-0.064	0.341*	0.578**	0.011	0.096
1000-grain weight (g)									-	-0.126	-0.006	0.166	0.120
Biological yield/plant (g)										-	-0.500**	-0.261	-0.281
Harvest index (%)											-	0.181	0.299
Malt (%)												-	0.047
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-22 : Phenotypic correlation coefficient of 13 characters in barley at environment-VII.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	0.060	0.293	-0.29	0.360*	-0.042	0.454**	-0.232	0.116	-0.023	-0.185	0.070	0.014
Days to maturity		-	-0.459**	0.080	-0.100	0.268	0.179	0.108	-0.075	0.183	0.040	0.047	-0.130
Plant height (cm)			-	-0.288	0.264	-0.307	0.113	-0.282	-0.110	-0.218	-0.056	0.036	0.179
No. of tillers/plant				-	-0.053	0.173	-0.084	0.341*	0.198	0.262	-0.096	0.045	-0.013
Ear length (cm)					-	-0.116	0.101	-0.303	0.127	-0.050	-0.213	0.183	0.061
No. of spikelets/plant						-	0.446**	0.422**	0.045	0.514**	-0.285	-0.388**	0.103
No. of seeds/plant							-	-0.074	-0.003	0.334*	-0.275	-0.174	-0.227
Grain yield/plant (g)								-	0.115	0.487**	0.476**	0.073	0.022
1000-grain weight (g)									-	-0.043	0.128	0.044	0.011
Biological yield/plant (g)										-	-0.426**	-0.089	0.117
Harvest index (%)											-	0.234	-0.171
Malt (%)												-	0.000
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

Table-23 : Phenotypic correlation coefficient of 13 characters in barley at environment -VIII.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.063	0.374*	-0.028	0.355*	-0.103	0.343*	-0.137	0.203	-.016	0.025	0.003	-0.276
Days to maturity		-	-0.371*	0.102	-0.293	0.265	-0.081	0.022	-0.287	0.296	-0.079	0.179	-0.115
Plant height (cm)			-	-0.126	0.478**	-0.195	0.116	-0.230	0.142	-0.309	0.082	0.125	0.075
No. of tillers/plant				-	-0.037	0.175	0.111	0.119	0.080	-0.311	-0.165	0.060	-0.001
Ear length (cm)					-	-0.218	0.103	-0.249	0.013	-0.185	-0.056	0.160	0.089
No. of spikelets/plant						-	0.067	0.387*	0.160	0.193	-0.077	-0.019	0.074
No. of seeds/plant							-	0.401*	0.002	0.304	-0.331*	-0.121	-0.098
Grain yield/plant (g)								*	0.403*	0.413*	0.548**	0.153	0.021
1000-grain weight (g)									-	-0.138	0.002	-0.099	0.0248
Biological yield/plant (g)										-	-0.441**	0.048	-0.192
Harvest index (%)											-	0.188	0.098
Malt (%)												-	0.175
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

(pooled data)

Table-24 : Phenotypic correlation coefficient () of 13 characters in barley .

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Days to flowering	-	-0.141	0.293	-0.021	0.395*	-0.112	0.372*	-0.186	0.184	–0.094	-0.093	-0.078	-0.173
Days to maturity		-	-0.534**	0.139	-0.387*	0.376*	-0.016	0.215	-0.209	0.264	-0.061	-0.124	-0.027
Plant height (cm)			-	-0.266	0.453**	-0.203	0.037	-0.373*	-0.025	-0.349*	-0.001	0.154	0.232
No. of tillers/plant				-	0.008	0.225	0.010	0.356*	0.070	0.343*	-0.148	-0.039	-0.170
Ear length (cm)					-	-0.308	0.131	-0.240	0.030	-0.236	-0.007	0.010	0.016
No. of spikelets/plant						-	0.432**	0.378*	0.037	0.479**	-0.255	-0.154	0.081
No. of seeds/plant							-	0.354*	0.094	0.394*	-0.557**	-0.279	-0.108
Grain yield/plant (g)								-	-0.103	0.544**	0.354*	0.188	0.031
1000-grain weight (g)									-	-0.123	0.087	0.121	0.268
Biological yield/plant (g)										-	-0.564**	-0.212	-0.062
Harvest index (%)											-	0.443**	0.089
Malt (%)												-	0.288
Starch (%)													-

*, ** Significant at 5 and 1 per cent levels, respectively.

while it had significant correlation with plant height (0.395) in environment-III and ear length (0.378 and 0.36) environment-VI and VII respectively. The pooled analysis also showed the positive significant correlation with ear length (0.395) and number of seeds per spike (0372).

2. Days to maturity

Days to maturity had positive significant correlation with biological yield per plant (0.336) in environment-IV, while highly significant negative correlation with plant height in all the environments except environment-II and-VI. The pooled analysis it showed positive significant correlation with number of spikelets per ear (0.376) and negative with ear length (-0.387) and highly significant negative correlation with plant height (-0.534).

3. Plant height (cm)

The character plant height had highly significant and positive correlation with ear length in environments-IV and VIII (0.562 and 0.478) and found significant at 5 per cent level in environment-II and III (0.382 and 0.350, respectively). Whereas, it had negative significant correlation with tiller number per plant in environment-III (-0.327), grain yield per plant -0.339, -0.326, -0.328 in environments-II, III, VI, respectively; biological yield per plant in environment-II (-0.348), V (-0.331) and VI (-0.339), number of spikelets per ear (-0.351) in environment-III. Pooled analysis revealed that the plant height exhibited positive and highly significant correlation with ear length (0.453) but negative with grain yield per plant (-0.373) and biological yield per plant (-0.349).

4. Number of tillers per plant

Tiller number per plant showed positive significant correlation with grain yield per plant in environments-II, III, IV, VI and VII with the values (0.386, 0.359, 0.358, 0.378 and 0.341, respectively). In environment-III and IV, it had also positive significant correlation with biological yield per plant (0.331 and 0 346, respectively). Pooled analysis revealed that the tiller number per plant positively and significantly correlated with grain yield per plant (0.356) and biological yield per plant (-0.349),

5. Ear length (cm)

The ear length exhibited positive significant correlation with grain yield per plant (0.379, 0.344) in environment-I and V. On the basis of pooled analysis the ear length does not have significant correlation with any other characters.

6. Number of spikelets per ear

The number of spikelets per ear had highly significant positive correlation with number of seeds per spike in environment-I (0607), III (0.444) and VII (0.446) and biological yield per plant in environment-III (0.543) and VII (0.514) while It had significant association yield per plant in almost all the environments excellent-IV and with number of seeds per spike and biological yield per plant in environment-II, V and VI. Negative and significant correlation was observed between number of spikelets per ear and malt percentage in environments-II, III and VII. The pooled analysis also showed positive and highly significant correlation with number of seeds per spike (0.432), and biological yield per plant (0.479) whereas it had significant positive correlation with grain yield per plant (0.378).

7. Number of seeds per spike

The character number of seeds per spike exhibited positive and highly significant correlation with biological yield per plant in environment-I (0.597) and V (0.535) and significant positive correlation in environment-IV (0.326) and VII (0.334) and with grain yield per plant in environment-V (0399) and VIII (0.401), while, it had negative and highly significant correlation with malt percentage in environment-II (0.352). The pooled analysis revealed that the number of seeds per spike had significant positive correlation with grain yield per plant (0.354) and biological yield per plant (0.394) while negative and highly significant correlation was also found with harvest index (-0.557)

8. Grain yield per plant

Grain yield per plant showed positive and highly significant correlation with number of spikelets per ear in environment-VII (0.422), biological yield per plant in environment-III (0.506), IV (0.440) and VII (0.487) and with harvest index in all the environments. while it showed significant positive correlation with tiller number per plant in environment-II (0.386) III (0.359) IV (0.378) and VII (0.341) with ear length in environment-I (0.379) and V (0.344), with number of spikelets per ear in almost all the environments except environment-IV, with number of seeds per spike in environment-V (0.399) and VIII (0.401) and it had positive and significant correlation with biological yield per plant in environment-I (0.406), II (0.326), V (0.342), VI (0.341) and VIII (0.413) and with 1000-grain weight in environment-V (0.391) and VIII (0.403). Negative and significant correlation was shown by the grain yield per plant with plant height in environment-II (-0.339), III (-0.326) and VI (-0.544) and positive significant correlation with biological yield per plant in (0.544)

and positive significant association with tiller number per plant (0356), number of spikelets per ear (0.378), number of seeds per spike (0.354) and harvest index (0.354).

9. 1000-grain weight (g)

The 1000-grain weight exhibited positive and significant correlation with grain yield per plant in environment-V (0.391) and VIII (0.403). But in pooled analysis it does not show significant correlation with any traits at phenotypic level

10. Biological yield per plant (g)

Biological yield per plant had positive and highly significant correlation with number of spikelets per ear in environment-III (0.543) and VII (0.514), number of seeds per spike in environment-I (0 597) and gram yield per plant in environment-III (0.506), IV II (0.487), besides this it had positive and significant with tiller number per plant in environment-III (0.331) and number of spikelets per ear in environment-I (0.408), V and VI (0.336), number of seeds per spike in environment-IV (26) and VII (0.334) and with grain yield per plant in environment-I (0.406), II (0.326), V (0.342), VI (0.342) and VII (0.413), ~~respectively, while~~, this trait also exhibited the negative and significant correlation with harvest index in all the eight environments. Pooled analysis also showed the same trend of ~~correlation coefficient~~.

11. Harvest index (%)

The harvest index showed positive and significant correlation with malt percentage (0.335) in environment-VII, and highly significant with grain

yield per plant in all environments with the values 0.469, 0.564, 0.541, 0.595, 0.447, 0.578, 0.476 and 0.548, respectively and negative and highly significant correlation with biological yield per plant in all the environments. Whereas, in pooled analysis, harvest index showed positive and highly significant correlation with malt percentage (0.443) and highly significant but negative correlation with biological yield per plant (-0.564), number of seeds per spike (-0.557) while, it had positive significant correlation with grain yield per plant (0.334).

12. Malt percentage

Malt percentage exhibited phenotypic correlation negative and significant with number of spikelets per ear in environment-II, III and VII (-0.366, -0.464 and -0.388, respectively) and with number of seeds per spike (-0.352) in environment-II. However, in environment-VII it had positive and significant correlation with harvest index (0.335). In pooled analysis, malt percentage showed positive and significant correlation with harvest index (0.443).

13. Starch percentage

At phenotypic level, it does not have any significant correlation with any traits across the environments as well as in pooled analysis.

4.5 PATH COEFFICIENT ANALYSIS

Since the mutual relationships of component characters may vary both in magnitude and direction and tend to vitiate the association of grain yield with other attributes, so it is necessary to partition the correlation into direct and indirect effects of each character. This can be done by applying path

analysis technique proposed by Deway and Lu (1959). This technique by further partitioning of the correlations into direct and indirect effects, established the cause and effect relationship among the yield and its component characters.

After partitioning the phenotypic correlation coefficient of grain yield per plant and its components it is necessary to partition the correlation into direct and indirect effects of each character. The results of path analysis are presented in (Table 25 to 33).

The characters, biological yield and harvest index had significant positive correlation with grain yield per plant. These traits also showed the maximum positive direct effects on grain yield. The harvest index had the values of direct effects from 1.161 to 0.822 in environment-II and VII, respectively while biological yield per plant showed direct positive effects on grain yield per plant ranging from 1.110 to 0.820 in environment-I and VIII, respectively.

Positive and significant correlation of tiller number per plant was observed with grain yield per plant in environments-II, III, IV, VI and VII but direct effects of this trait was observed low and negative in environments-VII (0.067), II (-0.014), III (-0.001), IV (-0.022) and VI (-0.005) indicating the significant correlation of these two variables was mainly due to the high indirect positive effect via biological yield per plant. Similarly number of spikelets per ear showed significant positive correlation with grain yield per plant in all the environments except environment-IV. The direct effect of this trait was positive and low in environments-I (0.029), II (0.019), V (0.089), VI (0.139), VII (0.077) and VIII (0.063) and negative direct effect in environment-III (-0.013), but it showed high indirect effects towards grain

Table-25 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -I.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.010**	-.008	0.008	0.010	-0.016	0.004	-0.009	-0.016	0.130	-0.139	0.005	0.004	-0.016
Days to maturity	0.003	**-0.027**	0.002	0.007	-0.014	0.003	-0.009	0.002	-0.052	0.184	0.010	0.001	0.111
Plant height (cm)	0.013	0.011	**-0.010**	0.012	-0.011	-0.013	0.011	-0.018	-0.276	0.060	0.006	0.001	-0.216
No. of tillers/plant	0.001	0.010	-0.013	**0.009**	0.005	0.004	-0.031	0.001	0.293	-0.080	0.014	0.010	0.223
Ear length (cm)	0.074	0.036	0.094	0.054	**0.025**	-0.005	0.009	-0.009	0.136	-0.075	0.038	-0.001	0.379*
No. of spikelets/plant	0.033	-0.003	0.050	0.063	-0.001	**0.029**	-0.023	0.006	0.453	-0.315	0.030	0.024	0.346
No. of seeds/plant	0.002	-0.013	0.001	0.006	-0.015	0.016	**-0.038**	0.006	0.662	-0.520	0.010	0.008	0.126
1000-grain weight (g)	-0.021	-0.002	0.001	0.011	-0.015	0.004	-0.016	**0.043**	-0.002	0.052	0.009	0.020	0.085
Biological yield/plant (g)	0.001	0.001	0.001	0.002	0.003	0.011	-0.022	-0.012	**1.110**	-0.698	0.003	0.007	0.406*
Harvest index (%)	-0.011	-0.004	-0.010	0.005	-0.005	-0.007	0.017	0.002	-0.679	**1.142**	0.019	0.001	0.469**
Malt (%)	0.009	0.001	0.022	0.010	-0.031	0.005	-0.021	0.003	-0.116	0.009	**0.020**	0.010	-0.099
Starch (%)	0.002	-0.008	-0.011	0.017	-0.015	0.004	-0.009	0.007	-0.036	0.207	0.011	**0.003**	0.173

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

Table-26 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -II.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.012**	0.008	-0.004	-0.005	-0.001	0.007	-0.014	0.005	-0.034	-0.31	-0.012	0.012	-0.056
Days to maturity	-0.001	**0.002**	0.002	-0.011	0.001	0.005	-0.009	-0.027	0.302	-0.185	0.020	0.018	0.117
Plant height (cm)	0.001	0.012	**-0.009**	0.003	-0.017	-0.012	0.001	-0.004	-0.356	0.026	0.004	0.004	-0.339*
No. of tillers/plant	0.001	0.060	0.002	**-0.014**	0.090	0.025	-0.001	0.083	0.184	-0.088	-0.002	0.046	0.386*
Ear length (cm)	-0.014	0.013	-0.031	0.014	**-0.046**	-0.058	0.009	0.001	-0.256	0.039	0.005	0.008	-0.326*
No. of spikelets/plant	0.030	0.028	0.061	0.006	0.032	**0.038**	-0.007	0.006	0.286	-0.103	-0.008	0.020	0.389*
No. of seeds/plant	0.003	0.017	0.011	-0.021	0.005	0.007	**-0.019**	0.003	0.251	-0.409	-0.021	0.001	-0.171
1000-grain weight (g)	0.002	0.006	0.001	-0.007	0.003	0.004	-0.012	**0.028**	-0.187	0.055	0.002	0.003	-0.103
Biological yield/plant (g)	0.011	0.020	0.003	-0.022	0.001	0.005	-0.016	-0.005	**1.021**	-0.688	-0.006	0.002	0.326*
Harvest index (%)	0.004	-0.011	0.010	0.001	0.008	-0.013	0.007	0.001	-0.605	**1.161**	0.005	-0.004	0.564**
Malt (%)	-0.006	0.009	-0.012	0.001	-0.001	-0.007	0.007	0.003	-0.251	0.268	**0.022**	0.006	0.039
Starch (%)	-0.001	0.002	0.003	0.002	0.009	0.001	0.002	0.001	-0.287	0.339	0.014	**-0.006**	0.053

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

Table-27 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -III.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.013**	0.003	-0.020	0.020	0.001	0.001	-0.022	0.001	-0.089	-0.196	0.001	0.007	-0.282
Days to maturity	-0.021	**-0.031**	0.013	0.008	0.007	-0.014	-0.007	0.010	0.176	-0.027	0.004	0.006	0.125
Plant height (cm)	0.005	0.015	**-0.027**	0.003	0.001	0.005	-0.001	0.007	-.0261	-0.262	-0.011	-0.001	-0.326*
No. of tillers/plant	-0.005	-0.003	0.009	**-0.001**	0.004	-0.003	0.041	0.034	0.312	-0.056	0.019	0.008	0.359*
Ear length (cm)	0.005	0.004	-0.009	0.004	**0.002**	0.001	-0.003	0.002	-0.105	-0.185	-0.013	0.006	-0.289
No. of spikelets/plant	-0.001	-0.009	0.009	0.033	0.045	**-0.013**	-0.005	0.085	0.512	-0.305	0.026	0.015	0.393*
No. of seeds/plant	0.006	-0.004	-0.012	0.011	0.002	-0.014	**-0.012**	0.005	0.277	-0.307	0.003	0.001	-0.044
1000-grain weight (g)	0.003	0.004	0.002	0.003	0.007	0.009	-0.021	**0.004**	-0.039	0.164	-0.004	0.004	0.136
Biological yield/plant (g)	-0.011	-0.006	0.007	0.014	0.004	-0.007	-0.003	0.002	**0.944**	-0.429	0.003	-0.011	0.506**
Harvest index (%)	-0.013	0.001	0.002	0.004	0.010	0.004	0.004	0.001	-0.423	**0.958**	-0.003	-0.005	0.541**
Malt (%)	-0.001	-0.011	-0.006	0.003	0.008	0.006	0.003	0.004	-0.208	0.262	**-0.012**	-0.001	0.048
Starch (%)	0.002	0.003	-0.025	0.020	0.010	-0.021	0.002	0.008	0.125	-0.121	0.001	**-0.005**	-0.003

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076 check

Table-28 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -IV.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**-0.004**	0.002	-0.008	0.001	0.006	-0.009	-0.008	0.003	-0.093	-0.032	0.005	0.003	-0.133
Days to maturity	0.004	**-0.030**	0.011	-0.012	-0.005	0.002	0.002	0.006	0.306	-0.081	0.001	0.001	0.206
Plant height (cm)	-0.002	0.014	**-0.023**	0.002	0.009	-0.001	-0.004	0.010	-0.260	0.030	0.001	-0.012	-0.236
No. of tillers/plant	0.001	-0.036	0.072	**-0.022**	0.061	0.042	-0.031	0.046	0.315	-0.140	0.019	0.031	0.358*
Ear length (cm)	-0.001	0.008	-0.013	0.001	**0.017**	-0.002	-0.003	0.001	-0.128	-0.113	0.001	-0.001	-0.234
No. of spikelets/plant	0.010	-0.009	0.004	-0.004	-0.004	**0.008**	-0.011	0.001	0.249	-0.067	0.001	-0.001	0.177
No. of seeds/plant	-0.001	0.003	-0.014	-0.011	0.002	0.001	**-0.024**	0.020	0.297	-0.367	0.001	0.001	-0.095
1000-grain weight (g)	-0.005	0.010	-0.003	-0.001	0.001	0.001	0.001	**0.001**	-0.085	0.021	0.004	-0.002	-0.057
Biological yield/plant (g)	0.001	-0.010	0.007	-0.006	-0.002	0.002	-0.008	0.001	**0.910**	-0.456	0.001	0.002	0.440**
Harvest index (%)	0.001	0.002	-0.001	0.003	-0.002	-0.001	0.009	0.001	-0.415	**1.001**	0.001	-0.002	0.595**
Malt (%)	0.001	-0.005	-0.004	-0.002	0.004	0.010	0.002	0.001	0.102	0.104	**0.005**	-0.012	0.203
Starch (%)	0.001	0.003	-0.023	0.020	0.002	0.001	0.003	0.001	0.169	0.190	0.001	**-0.012**	0.016

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

Table-29 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -V.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.052**	0.003	0.008	0.007	-0.026	0.011	0.010	-0.017	0.069	-0.124	0.013	0.007	0.017
Days to maturity	0.012	**0.013**	-0.029	0.001	-0.012	0.008	0.008	0.006	-0.053	0.011	0.015	0.013	0.095
Plant height (cm)	0.002	-0.009	**0.086**	-0.009	0.003	-0.026	0.020	-0.023	-0.283	0.139	-0.014	0.014	-0.099
No. of tillers/plant	0.004	0.003	-0.009	**0.088**	0.012	0.010	-0.004	0.006	0.214	-0.100	0.019	-0.004	0.239
Ear length (cm)	-0.004	-0.001	0.071	0.043	**0.075**	0.066	0.030	-0.020	0.061	-0.011	0.048	-0.018	0.344*
No. of spikelets/plant	0.010	0.032	-0.009	0.034	-0.002	**0.089**	0.120	0.017	0.294	-0.274	0.006	0.017	0.334*
No. of seeds/plant	0.102	0.072	-0.026	0.050	-0.006	0.036	**0.031**	0.069	0.456	-0.413	0.007	0.012	0.399*
1000-grain weight (g)	-0.005	0.061	-0.017	0.081	-0.013	0.069	0.080	**0.115**	-0.019	0.039	-0.023	0.023	0.391*
Biological yield/plant (g)	0.004	-0.007	-0.028	0.022	0.003	0.020	0.005	-0.003	**0.853**	-0.554	0.018	0.006	0.342*
Harvest index (%)	-0.007	0.001	0.012	-0.009	-0.002	-0.017	0.010	0.002	-0.485	**0.976**	-0.025	-0.011	0.447**
Malt (%)	-0.015	-0.009	0.009	-0.013	0.008	-0.003	0.009	0.021	-0.121	0.189	**-0.129**	0.006	-0.048
Starch (%)	0.002	0.002	0.012	-0.011	-0.013	0.010	0.010	0.026	0.052	-0.008	-0.007	**0.105**	0.178

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

Table-30 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -VI.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**-0.003**	0.008	-0.006	0.007	0.008	-0.004	-0.004	0.002	-0.094	0.017	-0.008	0.001	-0.076
Days to maturity	0.010	**-0.070**	0.025	-0.005	-0.004	0.012	-0.012	-0.004	0.270	-0.107	-0.005	-0.002	0.109
Plant height (cm)	0.006	0.017	**-0.098**	0.012	0.010	-0.013	0.009	-0.012	-0.293	0.019	0.007	0.003	-0.328*
No. of tillers/plant	0.040	-0.006	0.039	**-0.005**	-0.001	-0.001	-0.002	0.102	0.283	-0.063	-0.003	-0.005	0.378*
Ear length (cm)	-0.001	0.008	-0.028	0.001	**0.034**	-0.014	0.001	-0.001	-0.276	0.007	0.006	-0.002	-0.265
No. of spikelets/plant	0.030	-0.021	0.057	0.092	-0.012	**0.139**	-0.013	-0.001	0.289	-0.166	-0.019	0.001	0.376*
No. of seeds/plant	0.018	-0.003	0.001	-0.003	-0.009	0.014	**-0.035**	0.002	0.169	-0.302	-0.012	-0.012	-0.173
1000-grain weight (g)	0.009	0.018	0.014	-0.006	-0.001	-0.002	-0.004	**0.015**	-0.108	-0.016	0.010	0.003	-0.068
Biological yield/plant (g)	0.002	-0.002	0.033	-0.012	-0.011	0.013	-0.007	-0.002	**0.860**	-0.489	-0.018	-0.089	0.341*
Harvest index (%)	0.004	0.008	-0.012	-0.005	0.003	-0.008	0.011	0.008	-0.430	**0.977**	0.011	0.008	0.578**
Malt (%)	0.008	0.006	-0.012	-0.003	0.003	-0.017	0.007	0.002	-0.224	0.177	**0.059**	0.001	0.011
Starch (%)	0.010	0.004	-0.001	0.009	-0.013	0.001	0.003	0.002	-0.242	0.292	0.003	**0.028**	0.096

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

Table-31 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -VII.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.057**	-0.006	-0.010	-0.002	-0.028	-0.003	-0.069	0.002	-0.019	-0.152	-0.004	0.002	-0.232
Days to maturity	0.003	**-0.099**	0.016	0.005	0.008	0.021	-0.027	-0.002	0.153	0.033	-0.001	-0.003	0.108
Plant height (cm)	0.017	0.045	**-0.036**	-0.019	-0.020	-0.024	-0.017	-0.002	-0.182	-0.046	-0.001	0.004	-0.282
No. of tillers/plant	-0.002	-0.008	0.039	**0.067**	0.044	0.013	0.015	0.024	0.218	-0.079	-0.001	0.010	0.341*
Ear length (cm)	0.021	0.010	-0.009	-0.004	**-0.077**	-0.009	-0.015	0.03	-0.042	-0.175	-0.005	0.001	-0.303
No. of spikelets/plant	-0.002	-0.026	0.051	0.062	0.079	**0.077**	-0.068	0.021	0.429	-0.234	0.012	0.002	0.403*
No. of seeds/plant	0.026	-0.018	-0.004	-0.006	-0.008	0.034	**-0.153**	0.000	0.79	-0.226	0.005	-0.005	-0.74
1000-grain weight (g)	0.007	0.007	-0.006	0.013	-0.010	0.003	0.006	**0.021**	-0.036	0.106	-0.011	0.010	0.115
Biological yield/plant (g)	-0.001	-0.018	0.008	0.018	0.004	0.040	-0.051	-0.001	**0.835**	-0.350	0.003	0.002	0.487**
Harvest index (%)	-0.011	-0.004	0.002	-0.006	0.017	-0.022	0.042	0.003	-0.356	**0.822**	-0.007	-0.003	0.476**
Malt (%)	0.004	-0.005	-0.001	0.003	-0.014	-0.030	0.027	0.001	-0.074	0.192	**-0.030**	0.000	0.073
Starch (%)	0.001	0.013	-0.016	-0.008	-0.005	0.008	0.035	0.009	0.098	-0.140	0.008	**0.020**	0.022

*, ** Significant at 5 and 1 per cent levels, respectively. Residual effect = 0.0076

Table-32 : Phenotypic path coefficient analysis regarding direct and indirect effects of 13 characters in barley at environment -VIII.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**-0.034**	-0.014	-0.003	0.010	0.005	-0.007	-0.017	0.020	-0.103	0.023	0.005	-0.021	-0.137
Days to maturity	0.002	**0.070**	0.003	0.008	-0.012	0.017	0.003	-0.020	0.243	-0.073	-0.014	-0.009	0.217
Plant height (cm)	-0.013	-0.026	**-0.009**	0.001	0.007	-0.012	-0.004	0.010	-0.0252	0.076	-0.010	0.006	-0.230
No. of tillers/plant	0.001	0.007	0.001	**-0.003**	-0.001	0.011	-0.004	0.006	0.255	-0.152	-0.005	0.002	0.119
Ear length (cm)	-0.012	-0.020	-0.004	0.010	**0.014**	-0.014	-0.014	0.001	-0.0152	-0.051	-0.013	0.007	-0.249
No. of spikelets/plant	0.003	0.019	0.092	0.100	-0.003	**0.063**	-0.002	0.021	0.158	-0.071	0.002	0.006	0.387*
No. of seeds/plant	-0.012	-0.006	-0.001	0.326	0.071	0.020	**-0.036**	0.090	0.249	-0.304	0.010	-0.007	0.401*
1000-grain weight (g)	-0.010	-0.020	-0.021	0.072	0.080	0.070	0.020	**0.071**	0.113	0.002	0.008	0.018	0.403*
Biological yield/plant (g)	0.004	0.021	0.011	0.008	-0.003	0.012	-0.011	-0.010	**0.820**	-0.405	-0.004	-0.014	0.413*
Harvest index (%)	-0.001	-0.006	-0.004	0.004	-0.005	0.005	0.012	0.003	-0.362	**0.918**	-0.015	0.007	0.548**
Malt (%)	0.010	0.013	-0.011	0.006	0.002	-0.007	0.004	-0.007	0.039	0.173	**-0.081**	0.013	0.153
Starch (%)	0.009	-0.089	-0.001	0.010	0.001	0.005	0.004	0.018	-0.157	0.090	-0.024	**0.074**	0.021

*, ** Significant at 5 and 1 per cent levels, respectively. Residual effect = 0.0076

Table-33 : Phenotypic path coefficient analysis (Pooled analysis) regarding direct and indirect effects of 13 characters in barley.

Characters	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	1000-grain weight (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)	Correlation with grain yield/plant g)
Days to flowering	**0.022**	0.002	0.001	0.002	0.019	-0.006	-0.046	0.011	-0.105	-0.87	-0.002	0.002	-0.186
Days to maturity	-0.004	**-0.011**	-0.002	-0.011	-0.018	0.021	0.002	-0.013	0.294	-0.57	0.002	0.011	0.215
Plant height (cm)	0.006	0.006	**0.003**	0.002	0.021	0.011	-0.005	-0.002	-0.388	-0.001	-0.003	-0.003	-0.373*
No. of tillers/plant	0.010	-0.002	-0.011	**-0.007**	0.043	0.012	0.018	0.044	0.382	-0.137	0.001	0.002	0.356*
Ear length (cm)	0.009	-0.004	0.002	0.006	**0.047**	-0.017	-0.019	0.002	-0.262	-0.017	0.004	0.007	-0.240
No. of spikelets/plant	-0.002	-0.004	-0.001	0.002	-0.014	**0.055**	0.054	0.032	0.475	-0.237	0.019	-0.001	0.378*
No. of seeds/plant	0.008	0.188	0.076	0.034	0.036	0.024	**-0.0125**	0.030	0.439	-0.363	0.006	0.001	0.354*
1000-grain weight (g)	0.004	0.002	-0.100	-0.001	0.001	0.002	-0.012	**0.060**	-0.137	0.081	-0.002	-0.003	-0.103
Biological yield/plant (g)	-0.002	-0.003	-0.001	-0.003	-0.011	0.026	-0.049	-0.007	**1.113**	-0.525	0.004	0.001	-0.544**
Harvest index (%)	-0.022	0.001	0.018	0.001	0.009	-0.014	0.070	0.005	-0.628	**0.931**	-0.009	-0.008	0.354*
Malt (%)	-0.012	0.001	0.001	0.021	0.010	-0.089	0.035	0.007	-0.236	0.412	**-0.030**	-0.013	0.188
Starch (%)	-0.004	0.012	0.001	0.001	0.001	0.004	0.014	0.016	-0.069	0.083	-0.016	**-0.003**	0.031

*, ** Significant at 5 and 1 per cent levels, respectively.

Residual effect = 0.0076

yield per plant via biological yield per plant in environments-I, II, III and VI while in environment V, via biological yield per plant and number of seeds per spike, in environment VII via biological yield per plant, tiller number per plant and ear length and In environment-VIII via biological yield per plant, plant height and number of tillers per plant.

The character number of seeds per spike had positive and significant correlation with grain yield per plant in environments-V and VIII. The direct effect of this trait was low and positive in environment-V (0.031) and negative in environment-VIII (-0.036) but it showed positive high indirect effects via days to flowering and biological yield per plant in environment-V and via tiller number per plant and biological yield per plant in environment-VIII, towards grain yield per plant.

Thousand grain weight had positive and significant correlation with grain yield per plant in environments-V and VII, while the direct effects of this trait was positive and low on grain yield per plant in both the environments but this trait contributed towards grain yield per plant indirectly through days to maturity, tiller number per plant, number of spikelets per ear and number of seeds per spike in environment-V and in environment-VIII, ~~indirect effects were higher via biological yield per plant, tiller number per plant, ear length and number of spikelets per ear.~~ not clear

The character ear length showed positive and significant correlation with grain yield per plant in environments-I and V. Direct effects of this character was also low and positive but noted its indirect contribution towards ~~gram~~ grain yield per plant was via biological yield per plant and plant height in environment-I and via biological yield per plant and plant height and number of spikelets per ear in environment-V.

Two locations (pooled) data analysis of all the environments (Table-33) revealed that the biological yield per plant had maximum positive direct effect (1.113) on grain yield per plant followed by harvest index (0.931). The number of spikelets per ear and number of seeds per spike showed positive significant correlation with grain yield per plant. Their indirect effects were either low or negative but these traits contributed indirectly through biological yield per plant and days to maturity. Similarly, tiller number per plant had negative direct effect on grain yield per plant but correlation was positive and significant because of high indirect effect via biological yield per plant (0.382). The plant height had low positive direct effects but negative indirect effect via biological yield per plant was high on grain yield per plant which resulted into significant negative correlation between these two characters

The contribution of residual factor in pooled analysis (0.563) at phenotypically. It indicates that these thirteen characters contributes 99.68 per cent variability is explained towards grain yield per plant.

In general, the trend of yield contributing characters towards their contribution in grain yield per plant was observed to be similar in all the environments across location. The characters harvest index and biological yield per plant consistently showed high positive direct effect on grain yield per plant. Whereas, the characters number of tillers per plant, number of spikeletes per ear, number of seeds per spike had low direct effect but contributed towards grain yield per plant mainly through biological per plant.

The 1000-grain weight showed low direct effects on grain yield per plant but contributed towards grain yield per plant via days to

maturity, number of tillers per plant, number of spikelets per ear, number of seeds per spike and biological yield per plant. The remaining characters showed rather negligible or inconsistency in their contribution towards grain yield per plant.

4.6 PHENOTYPIC STABILITY ANALYSIS

1.6.1 Joint regression analysis

The pooled analysis of variance for different character is presented in (Table-34). The mean squares due to varieties were found significant for all the characters except ear length indicating the presence of sufficient genetic variability for these characters. The mean square due to environments were found significant for all the characters studied .The linear component due to environment were also recorded significant for all the characters understudy suggesting the linear component of the environment counted for the major portion of the environment variance. The variety x environment interactions effect was found to be significant for nine characters namely, Days to flowering, days to maturity, plant height, ear length, number of spikelets per ear number of seeds per spike, harvest index, malt percentage and starch percentage showing the differential response of the varieties in eight different environments for these characters.

4.7 STABILITY ANALYSIS

The stability analysis was carried out using the phenotypic mean value across the eight environments for different characters following one approach in Eberhart and Russell (1966) model. In this model two parameters were estimated as :

Table-34 : Analysis of variance for thirteen characters in forty genotypes of barley (Pooled analysis).

Source	D.F.	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Ear length (cm)	No. of spikelets per plant	No. of seeds per spike	Grain yield per plant	1000-grain wt. (g)	Biological yield per plant (g)	Harvest index (%)	Malt (%)	Starch (%)
Varieties (V)	39	74.47**	67.03**	99.47**	12.00**	0.68	152.34**	145.34**	6.82**	42.97**	44.18**	114.84**	14.29**	13.20**
Environments (E)	7	261.24**	353.69**	272.72**	37.05**	5.53**	569.85**	301.09**	48.48**	24.45**	117.00**	144.06**	129.99**	120.89**
V x E	273	1.93**	3.40**	2.84**	0.33	8.10**	11.81**	3.98**	0.39	0.27	0.89	7.70	4.10**	3.71**
Pooled Error	624	10.86	18.05	15.61	0.10	9.48	5.15	4.12	0.15	0.91	1.01	2.13	1.88	1.15
Envvironment + (V x E)	273	9.34	13.41	10.55	1.37	0.23	27.75	12.47	1.76	0.96	4.21	11.59	7.70	7.05
Environment (Linear)	1	1828.46**	2475.97**	1911.17**	259.37**	38.70**	3988.65**	2107.74**	339.38**	171.12**	819.10**	1008.03**	907.96**	846.72**
V x E (Linear)	39	3.38**	9.95**	2.37**	1.13	0.16	26.44**	14.42**	1.51**	0.33	1.93**	23.90**	8.49**	5.83**
Pooled Deviation	233	1.64**	2.25**	2.82**	0.19	6.58**	9.10**	2.18**	0.19	0.25	0.70	4.85**	3.29**	3.25**

** Significant at 1 % level.

(i). Linear sensitivity coefficient (b) *i.e.,* regression coefficient of an individual mean on environments index to evaluate cultivar response.

(ii). Non-linear sensitivity coefficient (S^2di) *i.e.,* mean square direction from the linear regression to measure cultivars stability. Characters ~~results for~~ mean performance and stability parameters have been presented in (Table-35) and described in the following text.

1. Days to flowering

The mean performance of the different varieties for the days to flowering ranged from 88.34 (K-633) to 100.03 (K-141) with population mean of 94.53. Out of 40 varieties, twenty five varieties had (b=1) close to unity showing average response to the environments. Eight varieties had b>1 indicating their better adaptation to favourable environments while seven varieties had b<1 showing the least response to the environments. All forty varieties had $S^2di = 0$ indicating their consistent performance over the eight environments. Considering mean (<94.53), b=1 and $S^2di = 0$, the ten varieties namely, Jagrati, PL-781, K-169, K-252, K-370, K-551, Lakhan, K-1155, K-633 and Amber were identified as desirable for earliness and stable for days to flowering over the eight environments.

2. Days to maturity

The mean performance of the different varieties for the days to maturity ranged from 117.28 (K-633) to 129.12 (K-783) with population mean 124.33. Out of thirty five varieties twenty three varieties had b=1, close to unity, showing average performance to the environments, eight varieties had b>1 indicating their better adaptation to favourable environments while,

Table-35 : Stability analysis for forty genotypes of thirteen characters in barley.

S. No.	Genotypes	Days to flowering			Days to maturity			Plant height (cm)		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
1	RD-2684	92.75	1.21*	-1.25	122.87	1.05	-4.27	111.85	1.11	17.61
2	K-273	95.89	1.69**	0.40	125.50	0.89	-5.29	104.91	0.81	-4.85
3	Manjula	96.37	1.13	-2.72	122.92	1.99**	3.44	111.20	1.31*	-2.20
4	K-678	94.91	1.22*	-1.92	125.29	0.73*	-4.20	105.22	0.91	-3.90
5	Vijaya	90.90	0.76*	-1.58	120.40	0.58*	-4.81	106.06	0.52*	-3.46
6	Jagrati	92.33	1.17	-1.13	120.80	0.85	-5.46	117.02	1.30*	-0.56
7	Jyoti	99.80	1.23*	-2.28	128.83	0.68*	-5.82	107.53	0.71*	-1.30
8	PL—781	94.50	0.99	-1.33	123.36	1.00	-4.05	111.18	1.13	-4.26
9	K-169	91.43	1.06	-2.71	120.13	0.44**	0.11	107.76	0.77*	-4.57
10	K-252	91.84	0.91	-2.81	122.33	1.24*	-2.79	108.18	0.93	-3.65
11	BH-851	97.71	0.88	-3.50	127.46	0.85	-5.35	104.82	1.05	-4.89
12	K-370	88.18	1.04	-1.55	121.61	0.83	-4.30	112.00	1.45*	-1.41
13	K-729	95.01	1.00	-3.59	126.20	0.37**	-3.78	110.49	0.79*	10.03
14	BEU-73	96.43	1.00	-2.25	127.50	1.38*	0.75	113.41	1.08	-3.30
15	K-341	92.09	0.69*	-3.29	121.38	1.14	-5.84	105.12	1.05	-4.75
16	K-603	96.01	0.77*	-2.19	121.35	0.80	-2.96	109.53	1.24*	-0.44
17	K-683	98.27	0.53*	-1.23	129.12	0.89	-5.73	110.72	1.12	-2.40
18	K-792	95.82	0.88	-3.22	123.79	0.90	-5.39	106.68	0.96	-4.31
19	K-784	93.33	0.63*	-3.00	122.63	1.00	-4.77	103.24	0.79*	-4.36
20	K-409	95.30	0.86	-2.86	126.34	1.05	-3.67	110.99	1.06	-2.89
21	K-1149	95.81	1.11	-3.01	126.83	1.14	-4.81	114.76	0.87	-2.45

Table-35 Contd.....

Table-35 Contd…….

S. No.	Genotypes	Days to flowering			Days to maturity			Plant height (cm)		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
22	K-551	93.32	1.04	-3.24	122.32	1.26*	-4.06	111.04	1.15	-4.02
23	K-790	94.94	1.41*	0.60	124.75	1.54**	-4.25	105.41	1.04	-1.67
24	Lakhan	91.49	1.03	-2.94	123.12	0.69*	-0.04	108.64	1.02	-4.37
25	K-804	92.42	0.66*	-2.95	123.58	1.72**	2.01	114.25	0.91	-3.99
26	RD-2035	95.68	1.30*	-0.94	124.06	0.79*	-3.15	104.33	0.76*	-4.81
27	K-318	99.96	0.52*	-2.41	129.01	0.53*	-5.01	109.90	1.19	-2.57
28	K-1155	93.67	0.81	1.30	125.21	1.09	-5.70	111.18	0.84	-4.84
29	K-789	96.54	1.14	-3.27	128.16	0.94	-5.95	112.64	0.85	-2.51
30	K-633	88.34	0.80	-2.22	117.28	1.69**	-4.82	114.13	0.86	-4.22
31	K-791	96.79	1.25*	1.33	126.12	1.63**	-4.90	112.41	0.90	-5.09
32	K-794	96.57	1.28*	0.46	125.88	0.82	-2.36	109.22	0.92	-4.26
33	Amber	88.74	0.85	-2.86	121.71	0.89	-4.00	108.54	1.53**	-3.45
34	K-675	95.52	1.19	-1.47	125.88	1.05	-5.25	114.95	1.08	-3.71
35	K-141	100.03	0.98	-3.58	128.30	0.59*	-5.37	106.21	0.97	-1.30
36	K-508	92.00	0.69	-3.29	121.38	1.14	-5.84	105.12	1.05	-4.75
37	K-745	96.00	0.80	-2.19	121.35	0.80	-2.96	109.53	0.24	-0.44
38	K-713	98.35	0.53	-1.23	126.12	0.89	-5.73	110.72	1.12	-2.40
39	DL-65	95.90	0.85	-3.22	123.79	0.90	-5.39	106.68	0.96	-4.31
40	DL-88	93.30	0.60	-3.00	122.63	1.00	-4.77	103.24	0.79*	-4.36
Population mean		94.53			124.33			109.58		
Mean range		88.34 (K-633) to 100.03 (K-141)			117.28 (K-633) to 129.12 (K-783)			103.24 (K-784) to 117.02 (Jagrati)		

Table-35 Contd…….

Table-35 Contd.....

S. No.	Genotypes	Number of tillers per plant			Ear length (cm)			Number of spikelets per plant		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
1	RD-2684	8.09	1.12	0.34**	8.61	0.41**	0.01	58.63	1.32*	0.43
2	K-273	10.01	0.77*	0.15	8.77	0.82	0.01	62.67	1.31*	2.49
3	Manjula	8.39	0.68*	-0.03	9.57	1.61**	0.07	61.61	1.07	0.16
4	K-678	7.99	0.26**	0.02	9.02	1.02	0.00	61.17	1.53**	0.91
5	Vijaya	7.31	0.77	0.11	9.06	0.59*	0.03	51.74	0.91	-0.28
6	Jagrati	9.17	1.63**	0.60**	9.03	1.21	-0.02	54.08	0.50**	-0.42
7	Jyoti	8.66	0.41**	0.04	8.24	1.34*	0.00	58.74	0.89	10.82*
8	PL—781	7.96	0.38	0.05	8.24	1.33*	0.00	64.24	1.24*	1.80
9	K-169	10.40	1.18	0.02	8.46	1.05	-0.03	58.68	1.19	-0.54
10	K-252	10.69	1.40*	0.08	8.32	1.89**	0.24	61.16	1.40*	5.72
11	BH-851	9.27	0.90	0.40**	8.70	0.89	-0.03	60.39	1.18	1.57
12	K-370	8.94	1.18	0.08	8.95	0.69*	-0.02	63.11	0.64*	5.71
13	K-729	7.44	0.62*	0.32**	8.90	1.34*	0.04	64.49	1.55**	19.88**
14	BEU-73	8.18	0.77*	0.01	8.88	2.08**	0.32	63.73	0.80	-0.04
15	K-341	7.49	1.06	0.00	8.30	1.05	-0.02	64.59	0.54*	21.61**
16	K-603	10.49	1.59**	0.13	8.82	0.67*	-0.01	63.57	1.31*	6.54
17	K-683	10.93	1.56**	0.09	9.38	0.72*	-0.01	66.10	1.02	92.64**
18	K-792	9.99	1.61**	0.05	8.94	1.22*	0.00	61.73	0.41*	-0.09
19	K-784	11.83	0.72*	0.30**	8.88	1.17	0.00	66.39	1.06	-0.32
20	K-409	9.31	1.84**	0.13	9.04	0.92	-0.01	57.83	2.32**	7.96
21	K-1149	8.11	0.53*	0.38**	8.52	1.12	0.01	58.52	1.31*	-0.71

Table-35 Contd.....

Table-35 Contd.....

S. No.	Genotypes	Number of tillers per plant			Ear length (cm)			Number of spikelets per plant		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
22	K-551	10.07	0.88	0.22	9.06	1.07	-0.01	62.43	0.25**	-0.82
23	K-790	10.61	0.83	0.27**	8.68	0.95	0.01	63.73	0.30**	11.44*
24	Lakhan	9.61	1.14	0.66**	8.90	0.81*	0.08	61.77	0.40**	0.32
25	K-804	9.75	1.01	0.11	8.82	0.43**	0.03	67.10	0.25**	0.38
26	RD-2035	10.87	0.73*	0.07	8.97	0.65*	0.05	61.29	0.93	6.03
27	K-318	8.91	0.80	0.04	8.85	0.60*	-0.01	71.60	0.70*	19.39**
28	K-1155	8.06	0.62	-0.01	8.67	0.91	0.00	70.60	0.59*	6.05
29	K-789	9.32	1.12	0.12	8.94	0.82	0.06	59.85	0.52*	3.66
30	K-633	10.38	1.02	-0.12	8.75	1.36*	0.12	62.83	0.79*	-0.76
31	K-791	11.62	0.87	0.26**	9.16	1.23*	0.03	63.24	1.24*	0.31
32	K-794	9.65	1.01	0.08	9.02	0.63*	0.01	66.85	1.12	0.98
33	Amber	8.14	1.09	0.16	8.73	1.13	0.01	71.19	2.10**	7.27
34	K-675	9.75	1.21*	0.00	8.86	0.68*	0.22	67.26	1.18	29.27**
35	K-141	10.64	1.66**	0.03	8.80	0.62*	0.00	68.42	1.07	-0.85
36	K-508	7.49	-0.06	0.00	8.30	1.05	-0.02	55.59	0.54	8.61
37	K-745	8.49	0.59	0.13	8.82	0.67	-0.01	60.57	1.31	6.54
38	K-713	8.93	0.56	0.09	9.38	0.72	-0.01	59.10	1.02	9.64
39	DL-65	9.55	0.61	0.05	8.94	1.22	0.00	61.73	0.41	-0.09
40	DL-88	8.83	0.72	0.30	8.88	1.17	0.00	62.39	1.06	-0.32
Population mean		9.37			8.82			62.89		
Mean range		7.31 (Vijaya) to 11.83 (K-784)			8.24 (Jyoti) to 9.57 (Manjula)			51.74 (Vijaya) to 71.60 (K-318)		

Table-35 Contd.....

Table-35 Contd……..

S. No.	Genotypes	Number of seeds per spike			Grain yield per plant (g)			100-grain weight (g)		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
1	RD-2684	57.22	1.00	-1.05	10.02	2.12**	1.13**	25.06	1.31*	-.03
2	K-273	60.88	0.73*	-0.66	11.63	1.17	0.00	26.59	0.78*	0.12
3	Manjula	53.94	0.92	-0.22	10.79	1.66**	0.29*	25.84	0.68*	-0.26
4	K-678	59.52	1.24*	0.47	12.04	0.56*	0.15	26.19	0.92	-0.13
5	Vijaya	49.63	0.76*	-0.07	10.09	1.62**	0.23	25.67	0.78*	-0.25
6	Jagrati	49.89	0.71*	2.11	9.63	1.19	0.22	25.24	1.04	-0.21
7	Jyoti	55.94	1.14	2.18	9.93	1.28*	0.07	25.81	0.71*	0.20
8	PL—781	54.90	0.17**	3.50	11.14	0.81	0.71*	31.26	0.84	-0.19
9	K-169	54.45	0.96	1.30	12.10	0.93	0.04	30.06	1.11	0.21
10	K-252	60.83	0.74*	0.37	11.84	0.85	0.10	25.53	1.28*	-0.14
11	BH-851	60.14	1.65**	1.01	12.80	0.66*	0.09	26.39	1.46*	0.19
12	K-370	54.66	1.34*	0.36	10.98	0.68*	0.08	30.95	1.09	-0.12
13	K-729	59.75	0.93	-0.73	10.57	0.52*	0.10	31.08	0.96	0.10
14	BEU-73	59.67	1.39*	1.46	11.26	0.59*	0.16	28.22	0.98	0.02
15	K-341	58.25	0.79*	-1.06	12.01	0.42**	0.26	30.09	1.08	-0.05
16	K-603	60.93	0.52*	0.19	9.13	1.00	0.04	30.38	1.04	-0.16
17	K-683	63.05	0.54*	-1.01	11.02	0.82	0.04	25.57	0.90	-0.05
18	K-792	53.46	1.44*	1.01	11.85	0.91	0.01	30.05	1.19	-0.16
19	K-784	56.04	2.40**	10.08**	11.68	1.13	0.03	31.03	1.04	-0.15
20	K-409	52.66	0.99	-0.52	9.82	0.45**	0.13	25.31	0.84	-0.22
21	K-1149	54.96	1.41*	0.71	10.79	0.76*	-0.03	26.50	1.24*	-0.20

Table-35 Contd…….

Table-35 Contd.....

S. No.	Genotypes	Number of seeds per spike			Grain yield per plant (g)			100-grain weight (g)		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
22	K-551	53.72	1.14	-0.43	9.53	1.26*	-0.03	25.37	0.97	0.34
23	K-790	53.05	1.51**	1.19	11.09	1.28*	0.15	31.11	1.28*	-0.16
24	Lakhan	53.75	0.70	-0.86	12.18	1.30*	0.17	26.28	1.09	-0.19
25	K-804	53.76	1.95**	8.04*	11.34	1.31*	0.24	26.21	0.83	-0.17
26	RD-2035	58.54	1.04	-1.00	11.56	1.06	0.05	29.89	0.66*	0.04
27	K-318	60.76	0.64*	-0.55	10.69	1.59**	0.34*	26.49	1.19	-0.15
28	K-1155	61.69	1.06	-0.67	11.20	1.09	-0.05	25.38	1.09	-0.20
29	K-789	53.93	0.78*	-0.80	10.47	0.62*	0.16	31.19	0.84	-0.01
30	K-633	54.00	1.25*	0.08	11.22	1.00	-0.02	25.85	1.49*	0.28
31	K-791	57.22	-0.37**	6.38	12.07	0.79*	0.01	26.38	0.84	-0.11
32	K-794	56.31	0.80	-1.13	11.95	1.19	0.02	29.25	0.17**	0.31
33	Amber	67.21	1.05	-0.78	10.02	0.56*	0.07	25.78	0.82	-0.10
34	K-675	57.47	0.66*	0.11	12.03	0.49*	0.16	25.39	1.02	-0.10
35	K-141	68.23	1.02	-0.57	9.74	1.33*	0.06	30.00	1.44*	-0.08
36	K-508	55.67	1.39	1.46	11.26	0.59	0.16	26.22	0.98	0.02
37	K-745	53.25	0.80	-1.06	11.55	0.42	0.26	26.09	1.08	-0.05
38	K-713	60.93	0.42	0.19	9.15	1.00	0.04	27.38	1.04	-0.16
39	DL-65	59.05	0.49	-1.01	11.02	0.82	0.04	25.57	0.90	-0.05
40	DL-88	50.46	0.43	1.01	10.85	0.91	0.01	28.05	1.19	-0.16
Population mean		57.15			11.34			27.64		
Mean range		49.63 (Vijaya) to 68.23 (K-141)			9.13 (K-603) to 12.80 (BH-851)			25.06 (RD-2684) to 31.26 (PL-781)		

Table-35 Contd.....

Table-35 Contd.....

S. No.	Genotypes	Biological yield per plant (g)			Harvest index (%)			Malt percentage		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
1	RD-2684	27.96	1.08	2.14*	36.70	2.63**	23.72**	82.41	1.12	-0.48
2	K-273	30.84	0.93	-0.09	38.50	1.36*	-0.25	80.67	1.06	4.96**
3	Manjula	24.83	1.00	-0.25	43.86	2.49**	5.09*	81.06	1.16	1.07
4	K-678	25.83	0.79*	-0.12	47.62	-0.10**	3.33	81.70	1.18	-0.18
5	Vijaya	23.67	1.74**	0.30	43.81	1.19	1.42	80.03	0.53*	7.94**
6	Jagrati	20.85	1.33*	-0.20	48.10	1.09	1.06	83.87	1.22*	0.35
7	Jyoti	21.38	1.39*	0.01	47.82	1.30*	-0.63	79.84	0.74*	2.21
8	PL—781	27.35	1.10	-0.28	41.33	0.71	11.40**	81.62	1.47*	0.81
9	K-169	29.11	0.97	-0.22	42.28	0.88	1.34	79.42	0.84	2.78
10	K-252	29.25	1.32*	0.72	41.27	0.02**	6.95**	82.26	1.95**	8.53**
11	BH-851	29.91	1.38*	0.11	43.45	-0.20**	3.08	81.05	0.95	2.56
12	K-370	24.53	0.65*	-0.07	44.97	0.81*	2.40	83.13	2.02**	2.06
13	K-729	24.38	1.18	0.32	44.70	-0.62**	8.22**	82.92	1.77**	3.03
14	BEU-73	26.23	0.84	1.23	43.79	0.81*	19.08**	81.82	1.52**	1.75
15	K-341	28.12	1.27*	-0.11	43.59	-0.79*	6.89**	80.21	0.96	1.90
16	K-603	26.69	0.56*	0.14	34.47	1.43*	1.57	78.98	1.57**	0.83
17	K-683	30.26	1.09	-0.21	37.00	0.59*	1.06	79.81	0.69*	2.32
18	K-792	28.05	0.98	-0.25	43.09	0.87	1.01	81.69	1.17	0.56
19	K-784	25.61	0.83	0.04	46.47	1.75**	1.71	80.30	1.40*	1.59
20	K-409	27.05	0.95	0.45	36.50	0.31**	3.99	79.51	1.91**	1.79
21	K-1149	25.93	1.16	0.00	42.28	0.56*	0.78	79.67	-0.81	5.03**

Table-35 Contd.....

Table-35 Contd.....

S. No.	Genotypes	Biological yield per plant (g)			Harvest index (%)			Malt percentage		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
22	K-551	24.09	1.38*	0.61	39.58	1.06	0.40	80.56	1.13	1.29
23	K-790	26.40	0.59*	0.03	42.40	1.83**	7.12	81.13	1.18	1.40
24	Lakhan	25.89	0.66*	0.87	47.69	2.40**	7.66**	80.79	0.64*	3.62*
25	K-804	28.01	0.61*	6.76**	41.54	2.68**	5.15*	82.80	1.07	6.25**
26	RD-2035	27.88	1.26*	0.02	42.63	0.76*	0.40	82.66	-0.77	4.53**
27	K-318	27.04	0.83	0.44	40.06	2.38**	3.12	80.01	0.69*	2.67
28	K-1155	29.70	0.93	0.10	37.68	1.22*	0.27	79.15	0.19**	3.73*
29	K-789	24.38	0.71*	-0.20	42.81	0.46**	0.03	80.54	1.10	2.49
30	K-633	26.46	0.46**	0.06	42.75	1.61**	2.90	81.02	0.57*	1.24
31	K-791	29.30	1.01	0.01	41.73	0.58*	0.09	81.17	1.29*	5.82**
32	K-794	28.50	0.98	-0.31	42.59	1.45*	-0.13	81.71	0.84	1.42
33	Amber	28.41	1.30*	0.37	36.34	-0.19**	3.16	77.72	0.87	1.06
34	K-675	25.92	0.84	0.03	47.53	-0.12**	4.11*	81.03	0.68*	2.52
35	K-141	28.41	0.90	0.42	34.63	1.82**	7.71**	79.95	0.51*	3.77**
36	K-508	26.12	1.27	-0.11	43.59	-0.79	2.90	80.21	0.96	1.90
37	K-745	26.75	0.56	0.14	35.33	1.43	1.60	78.98	1.57	0.83
38	K-713	30.06	1.09	-0.21	37.00	0.60	1.00	79.81	0.69	2.32
39	DL-65	27.05	0.98	-0.25	43.28	0.87	1.33	81.08	1.17	0.56
40	DL-88	25.61	0.83	0.04	46.66	0.75	1.16	79.30	1.40	1.59
Population mean		26.80			42.04			80.92		
Mean range		20.85 (Jagrati) to 30.84 (K-273)			34.47 (K-603) to 47.82 (Jyoti)			77.72 (Ambar) to 83.87 to (Jagrati)		

Table-35 Contd.....

Table-35 Contd.....

S. No.	Genotypes	Starch percentage			S. No.	Genotypes	Starch percentage		
		Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)			Mean X	Regression coefficient (bi)	Mean square deviation (S^2di)
1	RD-2684	58.69	0.55*	0.28	22	K-551	58.07	0.33*	0.83
2	K-273	57.95	0.60*	1.07	23	K-790	58.22	1.15	2.73**
3	Manjula	58.35	1.22*	2.26*	24	Lakhan	58.50	1.14	0.55
4	K-678	58.46	1.55**	2.21*	25	K-804	60.01	0.78*	1.12
5	Vijaya	57.83	0.68*	1.17	26	RD-2035	57.77	1.41*	0.72
6	Jagrati	57.66	1.22*	-0.14	27	K-318	57.58	1.02	-0.03
7	Jyoti	58.55	1.56**	3.01**	28	K-1155	60.31	0.95	0.04
8	PL—781	59.21	0.94	1.27	29	K-789	58.43	0.78*	1.14
9	K-169	58.51	0.91	0.37	30	K-633	58.90	0.94	-0.09
10	K-252	57.67	1.25*	2.78**	31	K-791	58.07	0.88	-0.19
11	BH-851	58.60	0.77*	-0.22	32	K-794	59.37	1.14	1.29
12	K-370	64.87	3.28**	1.00	33	Amber	57.62	1.05	-0.18
13	K-729	59.59	0.52*	-0.21	34	K-675	58.23	0.93	2.01*
14	BEU-73	59.46	0.75*	1.58	35	K-141	58.31	1.13	-0.09
15	K-341	57.16	0.77*	0.92	36	K-508	57.88	0.09	0.89
16	K-603	58.22	1.13	0.40	37	K-745	58.22	1.20	0.43
17	K-683	58.45	0.59*	0.17	38	K-713	57.45	0.24	0.22
18	K-792	58.74	0.65*	1.03	39	DL-65	58.74	0.33	1.00
19	K-784	58.83	0.74*	0.52	40	DL-88	56.83	0.39	0.55
20	K-409	58.61	1.05	2.01*	**Population mean**		**58.69**		
21	K-1149	59.38	0.62*	0.22	**Mean range**		**57.16 (RD-2684) to 64.87 (K-370)**		

*,** Significant at 5 and 1 per cent levels, respectively.

nine varieties had b<1 showing least response to the environments. All thirty five varieties had $S^2di=0$ showing consistent performance over the eight environments. Considering mean (< population mean), b=1 and $S^2di=0$, the nine varieties namely RD-2684, Jagrati, PL-781, K-370, K-341, K-603, K-792, K-784 and Amber were identified as desirable for early maturity and stable for days to maturity over the eight environments.

3. Plant height (cm)

The mean performance of the different varieties for the plant height ranged from 103.24 (K-784) to 117.02 (Jagrati) with population mean (109.58). Out of forty varieties, twenty nine varieties had b=1, near to unity showing average response to environment. Five namely Jagrati, K-370, K-603 and Amber varieties had b>1 showing their better adaptation to favourable environments. While six varieties had b<1 showing least response to the environments, All thirty five varieties had $S^2di=0$ indicating consistent performance over the eight environments. Considering high mean (> population mean), b=1 and $S^2di=0$ fourteen varieties namely RD-2684, PL-781, BEU-73, K-783, K-409, K-1149, K-551, K-804, K-318, K-1155, K-789, K-633, K-791 and K-675 were selected as desirable and stable for plant height over eight environments.

4. Number of tillers per plant

Mean performance of different varieties for number of tillers per plant ranged from 7.31 (Vijaya) to 11.83 (K-784) with population mean 9.37. Twenty varieties had b=1 close to unity showing average response to the environment. Eight varieties namely, Jagrati, K-252, K-603, K-783, K-792, K-409, K-675 and K-141 had b>1, showing better response for favourable

environments while twelve, varieties had b<1, determine least response to the environments. Out of forty varieties, twenty five had $S^2di=0$ showing consistent performance over eight environments. Considering high mean (> population mean), b=1 and $S^2di=0$, only four varieties namely K-804, K-633, and K-794 were identified as desirable and stable for number of tillers per plant over eight environment.

5. Ear length (cm)

Mean performance of forty varieties for ear length ranged from 8.24 (Jyoti) to 9.57 (Manjula) with population mean 8.82, twenty varieties showing average response to environments had (b=1) while nine varieties namely, Manjula, Jyoti, PL-781, K-252, K-729, BEU-73, K-792, K-633, K-791 had b>1, showing better adaptation to favourable environments. Eleven varieties had b<1, least responsive to the environments. Thirty five varieties showing consistent performance over the eight environments had $S^2di=0$. Based on high mean, b=1 and $S^2di=0$, seven varieties were selected as desirable and stable for ear length over eight environments. namely K-678, Jagrati, K-784, K-409, K-551, Lakhan and K-789.

6. Number of spikelets per ear

Mean values ranged from 51.74 (Vijaya) to 71.60 (K-318) with population mean (62.89) of thirty five varieties for number of spikelets per ear. Out of forty varieties, seventeen varieties had b=1 close to unity, showing average performance to the environments. Eleven varieties had b>1, namely, RD-2684, K-273, K-678, PL-781, K-252, K-729, K-603, K-409, K-1149, K-791 and Amber showing better adaptation to favourable environments. While twelve varieties showing least response to the environments with b<1. Out

of forty varieties, twenty eight varieties had $S^2di=0$ showing their consistent performance over eight environments. Considering high mean (> population mean), b=1 and $S^2di=0$, four varieties namely, BEU-73, K-784, K-141 and K-794 were identified as desirable and stable for number of spikelets per ear over eight environments.

7. Number of seeds per spike

Mean performance of forty varieties for number of seeds per spike ranged from 49.63 (Vijaya) to 68.23 (K-141) with population mean 57.15. Seventeen varieties had b=1 showing average response to the environments. Ten varieties namely, K-678, BH-851, K-370, BEU-73, K-792, K-784, K-1149, K-790, K-804, K-633 had b>1 showing their better adaptation to the favourable environments, while thirteen varieties namely, K-273, Vijaya, Jagrati, PL-781, K-252, K-341, K-603. K-783, Lakhan, K-318, K-789, K-791, K-675 had b<1, showing least response to the environments. Thirty three varieties had $S^2di=0$ indenting their consistent performance over the eight environments. Considering high mean (> population mean), b=1 and $S^2di=0$, six varieties namely, RD-2684, K-729, RD-2035, K-1155, Amber and K-141 were screened as desirable and stable for number of seeds per spike over eight environments.

8. Grain yield per plant (g)

Mean values ranged from 9.13 (K-603) to 12.80 (BH-851) with population mean (11.34) of forty varieties. Twelve varieties showing average response to environments because these genotypes having regression coefficient close to unity. Eleven varieties namely, RD-2684, Manjula, Vijaya, Jyoti, PL-781, K-551, K-790, Lakhan, K-804, K-318

and K-141 showing better adaptation to favourable environments with b>1 values while twelve varieties namely K-678, BH-851, K-370, K-729, K-341, K-409, K-1149, K-789, K-791, K-675 had b<1, showing least response to the environments. Out of forty varieties, thirty one varieties had $S^2di=0$ showing better performance over eight environments. Seven varieties showing high mean performance, b=1 and $S^2di = 0$ are identified as desirable and stable for grain yield per plant over eight environments namely K-273, K-169, K-252, K-792, K-784, RD-2035 and K-794.

9. 1000-grain weight (g)

The mean performance of different varieties for 1000-grain weight ranged from 25.06 (RD-2684) to 31.26 (PL-781) with population mean 27.64. Out of forty varieties, twenty seven varieties had b=1 showing average performance to the environments. Seven varieties namely, RD-2684, K-252, BH-851, K-1149, K-790, K-633, K-141 had b>1, showing better adaptation to favourable environments. However, six varieties had b<1, which showing least response to the environments. All thirty five varieties indicated consistent performance over eight environments as is evident from values of S^2di considering high mean value, b=1 and $S^2di=0$. Ten varieties namely, PL-781, K-169, K-370, K-729, BEU-73, K-341, K-603, K-792, K-784 and K-789, were selected as stable varieties over eight environments for this trait.

10. Biological yield per plant (g)

Mean value ranged from 20.85 (Jagrati) to 30.84 (K-273)with population mean 26.80 for biological yield per plant for fortyvarieties of barley. Out of forty varieties, twenty three varieties had b=1, showing average response

to environments, Nine varieties namely Vijaya, Jagrati, Jyoti, K-252, BH-851, K-341, K-551, RD-2035, Amber showing better adaptation to favourable environments with b>1 values while, eight varieties showing least response b>1 to environments. Out of forty varieties, thirty three had $S^2di=0$ showing better adaptation over eight environments. Considering high mean value, b=1 and $S^2di=0$, eleven accessions namely, K-273, PL-781, K-169, K-783, K-792, K-409, K-318, K-1155, K-791, K-794 and K-141 were screened as desirable varieties for biological yield per plant over eight environments,

11. Harvest index (%)

Mean performance of different varieties for harvest index ranged from 34.47 (K-603) to 47.82 (Jyoti) with population mean 42.04. Out of forty varieties, ten varieties had b=1, showing average response to the environments, Fourteen varieties had b>1, indicating better response to favourable environments, While sixteen varieties had b<1, showing least response to the environments. Only twenty four varieties had $S^2di=0$ showing consistent performance over eight environments. Considering high mean, b=1 and $S^2di=0$, four varieties namely, Vijaya, Jagrati, K-169 and K-792 were identified as stable varieties over eight environments for harvest index.

12. Malt percentage

Mean value ranged from 77.72 (Ambar) to 83.87 (Jagrati) with population mean of 80.02 for malt percentage ~~of forty varieties.~~ Out of forty varieties, sixteen varieties had b=1, showing average response to environments. Ten varieties namely, Jagrati, PL-781, K-252, K-370, K-729, BEU-73, K-603, K-

784. K-409, K-791, exhibited b>1, indicating better response to favourable environments. While nine varieties had b<1, showing least response to environments. Thirty varieties had $S^2di=0$ showing their consistent performance over eight environments. Considering mean, b=1 and $S^2di=0$ seven varieties namely, RD-2684, Manjula, K-678, BH-851, K-792, K-790 and K-794 were selected with high malt percentage yield over eight environments.

13. Starch percentage

Mean values ranged from 57.16 (RD-2684) to 64.87 (K-370) with population mean 58.69 for starch percentage of forty varieties. Out of forty varieties, nineteen varieties had b=1, showing average performance to the environments. Seven varieties namely, Manjula. K-678, Jagrati, Jyoti, K-252, K-370, RD-2035 exhibiting b>1, revealed their better adaptation to the favourable environments, while fourteen varieties had b<1, showing least response to the environments. Twenty seven varieties had $S^2di=0$ indicating their consistent performance over eight environments. Considering high mean, bi close to unity and $S^2di=0$ four varieties namely, PL-781, K-1155, K-633 and K-794 were detected as desirable and stable for starch percentage over eight environments.

Chapter-V

Disscusion

Chapter-5

DISCUSSION

Barley (*Hordeum Vulgare* L.) is an important cereal and hardy crop of ancient origin, grown world wide for food, feed and forage under varying agro-climatic conditions such as in rainfed areas, dry lands, saline, alkaline problematic soils and flood prone marginal and coastal areas. Barley has an advantage over wheat in terms of yield and quality of B glucon, soluble fiber protein, lysine and malt extract, and for its cooling and soothing effect under limited resources. Barley affords lower cost of cultivation and better price. In areas ~~which have~~ only a brief rainy season, ~~growers harvest~~ mainly barley crop. Barley has advantage ~~in aspect~~ such as salt tolerance, frost tolerance, ~~an early~~ period of development, drought tolerance etc. with great adaptive potential in many regions of the world.

In India, barley is grown in regions where the growing season is too short or the rainfall is inadequate for cultivation of other cereals. Most of the barley varieties have hulls and are useful for making bear or feeding cattle but the hulls must be removed before the grain can be eaten by humans. During last few decades due to ~~progress~~ in agriculture and ~~easily~~ availability of fine grains cereals like wheat and rice, it has been pushed to be utilized only as feed/industrial crop. Recent reports have shown a general declining trend in both production and acreage of barley. In order to stop this declining trend, high yielding varieties with stability ~~of production~~ are needed.

The success that a plant breeder can achieve depends on the correspondence between ~~phenotypic~~ and breeding value, if it is absent

then selection is ineffective. The main aim of any crop breeding programme is to evolve a variety which has high yield potential across the environmental regions. Yield is the ultimate result of interaction of genetic and environmental factor and controlled by polygene. According to Grafius (1964) and White House *et al.*, (1958), there may not be genes for yield per se but for their components, the multiplicative interaction of which results in ultimate yield. It would be therefore desirable to have information on component characters and their relationship with *vis* a *vis* among components themselves. Large variability ensures better chance of obtaining new derived forms. Statistical analysis like range, mean, coefficient of variability, heritability and genetic advance provide information on variation at phenotypic level and simultaneously give an indication of the influence of environment that bring about the variation.

In the present investigation an attempt has been made to measure the variability for various characters, their heritability, genetic advance, character association, path coefficient and stability.

GENETIC VARIABILITY

Genetic variability may be discussed under following sub heads.

Analysis of variance

Pooled analysis of variance (Table-2) disclosed that mean square due to treatments were significant for all the traits except ear length. This indicated the presence of considerable genetic variability for these traits among the genotypes under study. Similar results were also reported in this crop by Yadav *et al.*, (1991), Ram Kishor *et al.*, (2000) and Pilania and Dhaka (2005).

Range of Variation

In present study, the estimates of genetic components of variance, heritability and genetic advance have provided useful information on the magnitude of phenotypic and genotypic coefficient of variation. Variability in the population especially in respect to the characters for which improvement is sought is a prerequisite for successful selection.

Phenotypic coefficient of variability (PCV) was higher than corresponding genotypic coefficient of variability (GCV) presented in Table-12 and 13. This is because of the fact that variability at phenotypic level includes genotypic and environmental variability. These findings are similar to Chauhan *et al.*, (1988), Ram Kishor *et al.*, (2000) and Pilania and Dhaka (2005)..

On the basis of pooled analysis, phenotypic coefficient of variation for different characters ranged from 13.10 to 1.77 in all the environments whereas, genotypic coefficient of variation ranged from 12.64 to 1.07 in all the environments.

The high estimates of PCV and GCV values were observed for tiller number per plant. Number of spikelets per ear, number of seeds per spike, grain yield per plant, biological yield per plant, 1000-grain weight and harvest index, indicated the presence of ample genetic variability in the experimental material for these characters. High estimates of PCV and GCV for different characters in barley were also reported by Chauhan *et al.*, (1988), Sharma and Maloo (1994) and Sajeda Begum *et al.*, (1997), Ram Kishor *et al.*, (2000), Pilania and Dhaka (2005) and Dhama (2007).

The lowest PCV and GCV values were observed for malt percentage, starch percentage and days to maturity indicating that these traits exhibited low variability, which suggest that more variability should be generated for these traits, through hybridization or mutation breeding.

The maximum GCV has also been reported in barley for grain yield per plant and number of grains per spike (El-Hennawy, 1997). These findings are similar to our results, indicating that considerable improvement in grain yield and number of grains per spike, could be ought about by adopting a suitable breeding programme. The lowest GCV were recorded for plant height, 1000-grain weight and grain yield per plant by (Yadav *et al.,* 1993) and (El-Hennawy 1997). Whereas in present study, GCV was observed high for 1000-grain weight and grain yield per plant.

On the basis of these results it is concluded that the characters tiller number per plant, number of spikelets per ear, number of seeds per spike, grain yield per plant, biological yield per plant, 1000-grain weight and harvest index showed high variability. Therefore, greater emphasis should be given to these characters as selection based on these characters will be effective.

Heritability

The estimates of heritability in broad sense which determine the portion of the observed variance for which the differences in heritability is responsible, were obtained for several characters. Success in selection programme depends primarily on magnitude of heritable portion of total variation. Burton and De Vane (1953) suggested that genetic coefficient of variation, together with heritability estimates would give relatable indication

of the extent of improvement expected from selection and further explained that expected genetic advance under a particular system supplies a true practical information that is needed by breeders.

Broad sense heritability estimates of all the characters studied are given in Table-14. High heritability estimates were observed for number of tillers per plant, harvest index, grain yield per plant, 1000-grain weight, number of spikelets per ear, number of seeds per spike, biological yield per plant, malt percentage and starch percentage. It indicated that these traits are highly heritable and less affected by the environments. Therefore, selection should be based on these traits. Sajeda Bagum *et al.,* (1997) reported that all the traits studied possessed high heritability values, the highest being of grain yield per plant. Whereas. Kaeppler *et al.,* (1991) reported the heritability of Alpha-amylase activity on an F_2 plant basis ranged from 0.37 to 065, while on an F_5 basis it ranged from 0.39 to 0.74.

High heritability has also been reported for number of tillers per plant and grain per spike (Yadav *et al.,* 1991, El-Hennawy 1997), high heritability for 1000-grain weight (Yadav *et al.,* 1993) and for grain yield per plant (Nadziak *et al.,* 1994; Lu *et al.,* 1995; Vimal and Vishwakarma 1998; Sinha *et al.,* 1999, Kumar, 2003 and Dhama, 2007).

In this study, plant height, days to flowering and ear length exhibited moderate heritability, indicating that these traits are more influenced by the environments. Therefore, selection may not be so useful in improving these characters. In earlier studies, high heritability was observed for plant height (Nadziak *et al.,* 1994; Kudla *et al.,* 1995) and for ear length (Nadziak *et al.,* 1994; Ram Kishor *et al.,* 2000 and Pilania and Dhaka 2005). However, only one character namely days to maturity

showed low heritability in the present investigation which has also been reported by Leelu Babu 1998).

Genetic Advance

Heritability and GCV are not sufficient to determine the amount of variation which is heritable from parents to their off springs. Burton (1953) and Johnson *et al.*, (1955) found that the high heritability estimates alone is of little use in predicting the breeding value of any trait and therefore, this parameter can be better utilized in association with genetic advance and the heritability coupled with genetic advance gives an idea of the possible improvement through selection.

High heritability coupled with high genetic advance over mean (Table-15) was observed for tiller number per plant, biological yield per plant, harvest index, 1000-grain weight, grain yield per plant, number of seeds per spike and number of spikelets per ear indicated that additive genetic effects are of probable importance (Panse 1957) and improvement in this traits may be achieved through selection (Jonson *et al.*, 1955). High genetic advance with high heritability for number effective tillers per plant, length of spike, number of spikelets per main spike and grain yield per plant was also observed by Aidum *et al.*, (1990) in barley and Pathak and Namu (1985) in wheat.

Similarly, high heritability coupled with high genetic advance was noted for number of tillers per plant, ear length, spikelets per ear and grain yield per plant by Vimas and Vishwakarma (1998) and for number of seeds per spike, 1000-grain weight and grain yield per plant by Leebu babu *et al.*, (1998); Ram Kishor *et al.*, (2000) and Pilania and Dhaka (2005). Sajeda

Begum *et al.*, (1997) reported that the genetic advance was high for grain yield per plant, while Sinha *et al.*, (1999) found high heritability with low genetic advance for grain yield per plant.

Plant height, ear length, days to flowering, malt percentage and starch percentage exhibited low genetic advance with moderate heritability estimates indicating ~~the presence~~ that the direct selection for these traits in segregating populations will not contribute for the genetic improvement of ~~grain yield in barley~~. of Trait traits in barley.

CORRELATION COEFFICIENTS

In the present investigation, correlation among ~~13 characters and direct and indirect contribution of 12 characters~~ the 12 yield components and also towards the grain yield were estimated from the data recorded on 40 genotypes of barley in eight environments as well as in pooled analysis. The results are presented in table 16 to 24, ~~and 25 to 33, respectively.~~

The grain yield of a crop is a complex character and is the ultimate product of actions and interactions of various component characters. Further, it is well known that no independent gene system is present for the grain yield *per se*, but genes are available only for component characters (Grafius, 1969). Therefore, a successful breeding programme should depend not only on the information on association of various yield component characters with grain yield but also on the information of their inter association. Correlation of yield and some desirable characters with other characters should also be studied, because sometimes the selection on the basis of component characters of yield may not be effective due to low heritability. Therefore, it may become necessary to make selection on

the basis of characters other than the yield contributing characters. In view of this, the information on nature and magnitude of correlation between various characters is of outmost importance for initiating any successful breeding programme.

Every aspect of the phenotype of a plant is the result of a large number of factors. There are evidences to suggest that selection for yield is not so easy. Selection for one character invariably affects a number of other characters also. Thus, one realizes that it is the whole integrated genotype that is being selected rather than the particular part that is responsible for the characters we are selecting for.

In present study, the magnitude of genotypic correlation coefficient is higher than corresponding phenotypic correlation. The same results were also observed by Singh, (1987); Ram Kishor *et al.,* (2000) Kumar, 2003 and Dhama, 2007.

In present investigation, grain yield per plant was found consistently associated positively and significantly with biological yield and harvest index in all the environments as well as in pooled analysis. These results are in conformity with Theoulakis *et al.,* (1994) and El- Hennawy (1997). Grain yield per plant was correlated significantly with number of spikelets per ear in all the environments except environment-IV, and with tiller number per plant in five environments. The same pattern was observed by Yadav (1993), Irfan-ul Haq (1997), Singh *et al.,* (1998). Subash *et al.,* (1998), Khodzhakulu (1980), Ram Kishor *et al. (2000), Bhattacharya, (2005) and Dhama, (2007).* This emphasizes that the characters biological yield per plant, harvest index, number of spikelets per ear and tiller number per plant are more important attributes in determining

grain yield in barley. Their importance in yield improvement is further substantiated with the fact that they had significant positive association with other component characters. Some more characters like, ear length, number of seeds per spike and 1000-grain weight was observed to have positive significant correlation with grain yield showing their relative importance. Similar results were observed by El-Hennawy (1997), Irfan-ul-Hag (1997), Singh *et al.*, (1998) and Ram Kishor *et al.*, (2000). A negative but significant correlation was also observed between plant height and grain yield per plant in three environments as well as pooled analysis while, Hadjichirstodoutce A (1991), Ram Kishor *et al.* (2000), Dhama, (2007) and Singh and Khare (2008) reported that the plant height had positive and significant correlation with grain yield.

The character biological yield per plant was found consistently correlated negatively and significantly with harvest index across the environments, while it had positive significant correlation with number of spikelets per ear in five environments. For instance, biological yield with number of spikelets per ear, grain yield, number of seeds per spike in majority of the environments, number of spikelets per ear with number of seeds per spike in seven environments, number of seeds per spike with grain yield and biological yield. Number of tillers per plant with grain yield per plant and biological yield per plant in five and three environments, respectively showed positive and significant correlation.

In contrast, number of spikelets per ear was ~~also~~ associated negatively with malt percentage. Harvest index showed negative significant correlation with number of seeds per spike in five environments as well as in pooled analysis. Some other characters, plant height had negative

correlation with grain yield per plant in three environments while days to maturity consistently associated negatively with plant height in all the ~~entire~~ environments.

Keeping the above results ~~and discussion~~ in view, while selection for better genotypes in barley over a range of ~~given~~ environments, The the characters biological yield per plant, tiller number per plant, harvest index and number of spikelets per ear ~~have high correlation with grain yield and~~ are ~~thus~~ the main contributors for ~~improving~~ grain yield. Therefore, the simultaneous selection for these traits should be aimed ~~at yield~~ for the yield improvement in barley.

PATH COEFFICIENT

Correlation coefficient analysis provides only the direction and degree of association between various characters but, do not clearly bring out the characters on which breeder should concentrate to improve the productivity or yield potential of a crop. Therefore; path coefficients analysis was also carried out in the same material. This estimates the direct ~~effects~~ and indirect effects of various characters towards grain yield. The correlation coefficients of grain yield with various component characters were further analyzed by following path coefficients analysis.

The estimates of direct and indirect effects of various characters on grain yield are presented in Table-25 to 33. It would be interesting to note that the characters recommended earlier on the basis of correlation studies, showed consistently high direct effects and indirect effects through each other towards dependable variable. The characters biological yield per plant and harvest index exhibited high direct contribution towards grain yield.

The other important yield contributing characters namely number of spikelets per ear and number of seeds per spike had positive and significant correlation with grain yield per plant in majority of environments as well as in pooled analysis.

But these characters did not exhibit considerable direct influence on grain yield; instead, they contributed towards grain yield *via* biological yield. Whereas, Singh, 1987; Garcia, *et al.,* 1991; Ganeshva, *et al.,* 1992; Mandai and Dana, 1993; Naik, *et al.,* 1998; Verma, *et al.,* 1998; Fathi and Rezacimogholdam, 2000; Kumar, 2003 and Kumar and Khare, 2008 reported that the number of seeds per spike had greatest effect on grain yield. It is pertinent to mention that character tiller number per plant had positive and significant correlation with grain yield but it had negative direct effects on grain yield. However, it contributes towards grain yield *via* biological yield per plant. While Kumar, *et al.,* 1986; Jadav and Jadon, 1987; Singh, 1987; Sarker, *et al.,* 1988; Singh, 1990; Garcia, *et al.,* 1991; Yadav, 1993; Kudla, 1995; Maled, and Hanchinal, 1997; Naik, *et al.,* 1998; Verma, *et al.,* 1998; Fathi and Rezaeimoghddam 2000; Dhama, 2007 and Singh and Khare, 2008 observed the character tiller number per plant had positive and direct effect on grain yield per plant.

It is apparent from ~~the direct effect and high positive~~ correlations ~~with grain yield~~ that biological yield and harvest index ~~have~~ had true relationship with grain yield. Therefore, direct selection for high biological yield and high harvest index will result in improvement of grain yield in barley. Because, all other component characters had indirect effect on grain yield via these two characters, ~~correlated response in component characters will automatically be obtained~~

It is interesting to mention that important yield contributing trait, 1000-grain weight had positive and significant correlation with grain yield in only two environments and also have positive direct effects on grain yield in same environments. However, pooled analysis of correlation and path coefficient revealed that it does not have any influence on grain yield directly or indirectly on the contrary, Singh, 1987; Gansheva, *et al.,* 1992; Mandai and Dana, 1993; Kudla, 1995; Verma, *et al.,* 1998; Bhattacharya, 2005 and Singh and Khare, 2008 reported that 1000-grain weight had positive direct effects on grain yield. Therefore, it may be suggested that 1000-grain weight is not a stable selection criteria for yield improvement in barley, because other yield contributing characters like days to maturity, biological yield, grains per ear, tiller number per plant and number of spikelets contributes indirectly yield.

In spite of agronomic characters, quality traits like malt and starch percentage has important role to stabilize the barley as a raw product for different industrial purposes. In the present investigation malt percentage has positive and significant correlation with harvest index in pooled analysis whereas, it has negative and significant correlation with number of spikelets per ear in three environments. It also has negligible direct and indirect effects on most of the characters concerned. Therefore, it may be concluded that selection for harvest index can also improve the malt percentage along with grain yield in barley. However, character starch percentage did not show correlation, direct and indirect effects in the direction of yield improvement. Therefore, it necessitates formulating breeding procedures for starch percentage improvement.

It may also be important to mention that the phenomenal increase in barley yield potential during the past few decades is attributed to increased level of harvest index. The general consequence of this progression has been that the modern varieties are high yielding with shorter height but have little or no increase in overall biological yield over their fore bearers and further efforts to increase yield potential have not been successful. In barley, although the physiological limit for harvest index has been to 50 per cent, the further improvement of present level of harvest index has not been feasible. Therefore, the future improvement in grain yield of barley can be attained by increasing the biological yield, tiller number per plant and number of seeds per spike while maintaining the optimum not higher level of harvest index.

PHENOTYPIC STABILITY

It is realized that there is the importance of G x E interaction in predicting the performance of genotypes for their subsequent use in breeding programmes. The success of breeding programme depends upon the extent of genetic viability in the breeding material. The variable performance of genotypes under different environments makes it difficult for breeders to exploit the variability for different characters. Stability in performance is one of the most desirable properties of a genotype for selecting a parent for any breeding programme used to develop a variety best suited for wider cultivation. For this purpose the multi-location trials over a number of years are conducted. Some time the uni-location trials can also serve the purpose provided different environments are created by planting experimented trial at different date of sowing and providing various spacing, different doses of fertilizer and irrigation levels etc., (Luthra *et al.*,

1974). Whereas, Nissila *et al.,* (1992) concluded that the variation between years was highly significant and there was no interaction between genotypes and years.

Earlier Spargue (1966) discussed the importance of G x E interactions in estimating the variance components and described them as factors limiting the efficiency of selection programme. Although breeders have realized the importance of G x E interaction since the beginning of crop cultivation, yet efficient techniques were not available to quantify such interactions.

The regression analysis used by Eberhart and Russell (1966) and Perkins and Jinks (1968) is efficient in providing both the pooled estimates of G x E interactions for individual genotypes. Estimates of G x E interactions for each genotype could be further partitioned into linear components represented by regression coefficient (b=1) and non linear components represented by deviation from regression S^2di. Kara (1997) concluded that the mean yield was significantly correlated with coefficient of determination (r^2i). The linear regression (bi) statistic showed significant positive correlation with r^2i genotypic variance (S^2i) and coefficient variability (cvi). The covariance stability index (W^2i) and stability variance were perfectly correlated (r=1.00). The phenotypic performance of a genotype can be predicted if the G x E interaction is accounted for by linear components, such prediction can not be made if the non linear component is predominating. Keeping in view these points, the present study was undertaken to work out the phenotypic stability of 40 genotypes of barley (*Hordeum vulgare* L.) grown under eight environment over two different locations and the results thus, obtained are discussed here under.

Following the Eberhart and Russell (1966) model forty barley genotypes involved in the present study were observed to differ in their sensitivity, mean performance and stability for different characters.

Availability of different levels of mean performance and stability for a particular genotypes indicated that both the attributes are governed by different sets of genes. Therefore, sensitivity is specific characteristics of a genotype. Moreover, the nature and magnitude of sensitivity exhibited by different genotypes remained inconsistent for different characters. The genotypes were observed having different levels of mean performance and stability for various characters suggesting that the mean performance of genotypes were independent to their stability (Table-35). It may be assumed from these observations that there are different sets of genes governing both the attributes (mean performance and stability) for each character. Thus, it may be possible to incorporate both sets of genes in to the genotype to derive desirable cultivars with high mean and stable performance.

Commercially desirable genotypes should be stable with high and medium mean value. In the present study, the pooled analysis of variance for different characters is presented in (Table-34). The mean square due to varieties was found significant for all the characters except ear length, indicating the presence of sufficient variability for these characters. Costa *et al.*, (2001) and Pilania (2004) observed significant differences among barley cultivars and experimental lines for grain yield, plant height and heading date. and Sial *et al.*, (2000) also reported the combined analysis of variance over all environments revealed highly significant differences for genotypes, environments and G x E interaction. Whereas, Oliveira *et al.*,

(1994) concluded that the environment had a significant effect on four granules traits.

It is clear from results that the linear component of G x E interaction played an important role in all the thirteen characters under study. Genotype x location interaction from analysis of variance was reported significant for grain yield by the May *et al.*, (1993). Same findings were also found by the Fekadu Fufa *et al.*, (1995); Das, *et al.*, (1996); Salem, *et al.*, (1998); Forshadfar, (1999); Pilania, (2004) and Verma (2008) the genotype x environment interaction was higher than those of spikes per plant and seed weight. Upreti (1999) reported the presence of G x E interaction for all the traits except tillers per meter. The linear component G x E interactions was significant for days to heading, days to maturity, spike length, grains per spike and 1000-grain weight. However, Oliveira (1994) observed that G x E interaction was not significant. The non-linear components of G x E interaction were observed significant only for nine characters. Upreti (1999) also reported that the non linear component was significant for most of the characters except days to maturity, spike length and spikelets per spike the variance due to deviation (non-linear) were significant for days to flowering, days to maturity, plant height, ear length, number of spikelets per ear, number of seeds per spike, harvest index, malt and starch percentage reflecting considerable genetic diversity in the material.

1. Days to flowering

The mean performance of the 40 genotypes of barley for days to flowering ranged from 88.34 (K-633) to 100.03 (K-141) with the population mean 94.53. Considering the response of genotypes to environmental changes,

the genotypes Jagrati, PL-781, K-169, K-252, K-370, K-551, Lakhan, K-1155, K-633 and Amber showed early flowering with b=1 and non significant S^2di.

2. Days to maturity

The mean performance of different genotypes for days to maturity ranged from 117.28 (K-633) to 129.12 (K-783) with population mean 124.33. Considering low mean, b=1 and $S^2di=0$, only nine genotypes namely RD-2684, Jagrati, PL-781, K-370, K-341, K-603, K-792, K-784 and Amber were showing early maturity, with regression coefficient close to unity and deviation from regression zero.

3. Plant height (cm)

The genotype K-784 showed minimum plant height and stable having b<1 and non significant S^2di, while genotype Jagrati showed maximum plant height and non significant S^2di but their "bi" value was greater than unity therefore this variety perform better in good fertility levels.

4. Number of tillers per plant

Considering high mean value (>9.37), bi=1 and $S^2di=0$ four out of forty varieties namely, K-169, K-804, K-633 and K-794 were identified as desirable and stable for number of tillers per plant over eight environments. The genotypes K-784, RD-2684, Jagrati, BH-851, K-729, K-784, K-1149, K-551, K-790, Lakhan and K-791 had near medium mean values for number of tillers per plant and bi=1 but it had S^2di= significant these genotypes were not therefore suitable for cultivation in the environments studied because unpredictable components of G x E interaction.

considering in the performance of these genotypes. However, genotypes K-252, K-603 and K-783 were observed as high tiller producing genotypes and stable but its corresponding "bi" values were significantly greater than unity indicating that these genotypes perform better in favourable conditions and these varieties could be recommended for cultivation under better management practices.

5. Ear length (cm)

The mean values of different genotypes for ear length ranged from 8.24 (Jyoti) to 9.57 (Manjula) with population mean 8.82. The genotype Manjula was found maximum ear length producer from other genotypes and some more genotypes namely, K-804, K-789. K-784, K-409, K-551, Lakhan and K-789, were also maximum ear length producer genotypes and these genotypes had b=1 and $S^2di=0$, therefore these genotypes could be recommended for general cultivation.

6. Number of spikelets per ear

Using the stability criteria, high mean, b=1 and $S^2di=0$, out of 40 genotypes, four genotypes BEU-73, K-784, K-141 and K-794 were identified as desirable and stable for number of spikelets per ear over the eight environments. This could be recommended for commercial cultivation.

7. Number of seeds per spike

Mean performance of forty genotypes for this traits ranged from 49.63 (Vijaya) to 68.23 (K-141) with grand mean 57.15. Out of forty, six genotypes namely, RD-2684, K-729, RD-2035, K-115, Amber and K-141

were screened as desirable and stable for this trait. Therefore, these varieties are suitable for general cultivation under normal fertility levels.

8. Grain yield per plant (g)

Out of 40 varieties, thirty one genotypes showed stability for grain yield because these varieties had non significant deviation ($S^2di=0$) however, Hadjichristodolou (1974) reported that grain yield is a less stable trait in comparison to 1000-grain weight. Seven genotypes out of thirty one were stable for grain yield with high mean performance having unit regression and non significant deviation from regression over eight environments. These varieties are K-273, K-169, K-252, K-792, K-784, RD-2035 and K-794 which can be recommended for commercial cultivation ~~in the environments tested in the present study~~. Fekadu Fufa (1995) and Thakur *et al.*, (1999) ~~also~~ reported the genotypes PG-3510 (I), PG-3515 (I) and PG-319 (I) and DL-78 and DL-226 were stable for ~~high~~ yields and are suitable for commercial cultivation. Mishra *et al.*, (2000) ~~also~~ observed the genotypes DL-788-2 and GW 190 had higher adaptability and stability and may be recommended for normal and later sowing condition. All the seven ~~stable~~ genotypes for grain yield ~~per plant~~ with high mean performance showed stability for different characters ~~which are mention~~ (table-36). The variety K-273 showed stability and high mean performance, unit regression with biological yield per plant and harvest index. K-169 exhibited stability for days to flowering, number of tillers per plant, 1000-grain weight, biological yield per plant, harvest index and starch percentage. K-252 showed stability for days to flowering, the genotype K-792 showed stability for days to maturity, 1000-grain weight, biological yield per plant, harvest index and malt percentage and genotype K-784 showed stability for days to

Table-36 : Genotypes stable for grain yield with high and medium mean performance showing stability for other characters in barley.

S. No.	Genotypes	Grain yield/plant (g) Population mean	Category	Stable characters
1	K-273	11.63	H	Biological yield per plant
2	K-169	12.10	H	Days to flowering, number of tillers per plant, 1000-grain weight, biological yield per plant, harvest index and starch percentage
3	K-252	11.84	H	Days to flowering
4	K-792	11.85	H	Days to maturity, 1000-grain weight, biological yield per plant, harvest index and malt percentage
5	K-784	11.68	H	Days to maturity, ear length, number of spikelets per ear and 1000-grain weight
6	RD-2035	11.56	H	Number of seeds per spike
7	K-794	11.95	H	Number of tillers per plant, number of spikelets per ear, biological yield per plant, malt percentage and starch percentage
8	Jagrati	9.63	M	Days to flowering, days to maturity, ear length, 1000-grain weight and harvest index
9	K-603	9.13	M	Days to maturity, 1000-grain weight and starch percentage
10	K-783	11.02	M	Plant height, 1000-grain weight and biological yield
11	K-1155	11.20	M	Days to flowering, plant height, ear length, number of seeds per spike, 1000-grain weight, biological yield and starch percentage
12	K-633	11.22	M	Days to flowering, plant height, number of tillers pwer plant and starch percentage
Population mean		**11.34**		

maturity, ear length, number of spikelets per ear and 1000-grain weight indicating these varieties showing their consistent performance across the environments and it can be concluded that the varieties recommended for wider cultivation over the environments. Genotypes x environment interactions measured through regression analysis were significant for grain yield, heading date and plant height. Most barley genotypes tested (90%) had regression stole for grain yield that did not differ from 100 (Costa *et al.*, 2001, Pilania, 2004 and Verma, 2008).

Breeders main aim as emphasized earlier, is to have genotypes which are high yielding as well as stable for yield. The seven genotypes earlier recommended were high yielding as well as stable for yield. Noaman *et al.*, (1992) also identified five barley genotypes which exhibited both high yield and high stability. The genotypes K-678, BH-851, K-341, K-791, K-675 and K-804 were high fielding and stable but their corresponding "bi" values were significantly lower than unity. It shows that these genotypes would perform better in poor environment conditions hence these can be utilized as donor parent to breed a suitable line for poor environments. Mishra *et al.*, (2000) reported that the genotype DL-803-3 and Raj-1555 showed stability and sustainability under poor environmental conditions and may be recommended for cultivation under late sowing conditions. Similarly genotypes Lakhan, Vijaya, Jyoti, K-551, K-790, Lakhan, K-804 and K-141 were observed to be high yielding and stable but its corresponding "bi" values was greater than unity. It shows that these varieties would perform better in favourable conditions and hence could be recommended for cultivation under better management practices. Verma and Ram (1990) also identified the variety hulled BHO 113 and HBO 316 for high yield but suitability for better environment.

The genotypes RD-2684, Manjula, PL-781 and K-318 had low grain yield over the grand mean and significant S^2di hence were unstable. These genotypes were not therefore, suitable for cultivation in environment studied, because unpredictable components of G x E interaction considerably shared in the performance of these genotypes. Noaman *et al.* (1992) also reported that environment has influenced some genotypes, while some other genotypes were relatively consistent in ranking at different environment.

9. 1000-grain weight (g)

Out of forty varieties only ten varieties exhibiting high mean (>27.64), bi=1 and S^2di=0 were screened as desirable and stable for eight environments under study. Hadjichristodolou (1974) also reported that 1000-grain weight is most stable trait other than remaining yield contributing traits. However, he also concluded that six rowed varieties are less stable than two rowed varieties. While three genotypes namely, RD-2035, K-794 and K-141 had high mean performance and table but its corresponding "bi" values was lower than the unity, therefore, these varieties perform better under poor environmental conditions and these could be used as donor parent to breed a suitable line for poor environment.

10. Biological yield per plant (g)

Eleven genotypes were observed as desirable and stable with high mean (>26.80), bi=1 and S^2di=0 for biological yield per plant across the environments, while genotypes K-252, BH-851, K-341, RD-2035 and Amber had high mean performance and stable with S^2di=0 but its corresponding "bi" values were significantly greater than unity. Therefore, these varieties

perform better in favourable environments. However, genotypes RD-2684 and K-804 had greater mean performance with bi=1 but its S^2di= significant hence were unstable. These genotypes were not suitable for cultivation under environment studied, because G x E interaction plays major role for the performance of these genotypes.

11. Harvest index (%)

On the basis of mean performance, responsiveness and deviation from regression of individual genotypes the genotypes Vijaya, Jagrati, K-169 and K-792 were identified as stable for harvest index over eight environments and these genotypes performed better in normal environments.

12. Malt percentage

Considering high mean (>80.02), regression coefficient close to unity (bi=1) and deviation from regression zero the seven promising varieties namely, RD-2684, Manjula, K-678, BH-851, K-792, K-790 and K-794 were screened as desirable and stable for malt percentage over eight environments. These varieties could be recommended for commercial cultivation for malt percentage in the environments tested in the present study.

These seven stable genotypes for malt percentage with high mean performance (>80.02), had stability with different characters maintained against each genotype in Table-37. The genotypes K-273, Vijaya, K-252, K-1149, Lakhan, K-804, RD-2035, K-1155 and K-791 had medium malt percentage than population but significant S^2di hence were unstable therefore, these genotypes were not suitable for cultivation in the environments under study, as unpredictable components of G x E interactions considerably shared in the performance in these genotypes.

Table-37 : Genotypes stable for malt percentage with high and medium mean performance showing stability for other characters in barley.

S. No.	Genotypes	Malt percentage Population mean	Category (in terms of malt %)	Stable characters
1	RD-2684	82.41	H	Days to flowering, days to maturity and number of seeds per spike
2	K-678	81.70	H	Plant height and ear length
3	BH-851	81.05	H	Plant height
4	K-792	81.69	H	Days to maturity, plant height, grain yield, 1000-grain weight and biological yield per plant
5	K-790	81.13	H	Plant height, ear length, number of seeds per spike, grain yield per plant and 1000-grain weight
6	K-794	81.71	H	plant height, ear length, number of tillers per plant, number of spikelets per ear, grain yield per plant, biological yield per plant and starch percentage
7	K-169	79.42	M	Plant height, ear length, number of tillers per plant, ear length, number of spikelets per ear, number of seeds per spike, grain yield per plant, 1000-grain weight, biological yield per plant, harvest index and starch percentage
8	K-341	80.21	M	Days to maturity, plant height, number of tillers per plant, ear length and 1000-grain weight
9	K-551	81.56	M	Days to flowering, plant height, ear length, number of seeds per spike, 100-grain weight and harvest index
10	K-789	80.54	M	Plant height, number of tillers per plant, ear length and 1000-grain weight
11	Amber	77.72	M	Days to flowering, days to maturity, number of tillers per plant, ear length, number of sees per spike, 1000-grain weight and starch
Population mean		**80.92**		

On the basis of mean performance, responsiveness and deviation from regression of individual genotypes the genotypes Jagrati, PL-781, K-370, K-729, BEU-73 and K-675 were observed to be high yielding and stable but its corresponding "bi" values were significantly greater than unity. It shows that these genotypes would perform better in favourable conditions and hence could be recommended for cultivation under better management practices.

13. Starch percentage

In most of the breeding programmes, it is usually desired to identify promising genotypes for better, medium and poor environments. This can be done by using Eberhart and Russell (1966) model. Considering stability criteria the varieties PL-781, K-1155, K-633 and K-794 were identified promising for starch percentage under eight environments tested in present study. These four varieties showed stability with some other characters as mentioned against each genotype in Table-38. While, the genotypes RD-2648, K-729, BEU-73, K-792, K-784, K-1149 and K-804 had high starch percentage and were stable ($S^2di=0$) but the "bi" values were found significantly lower than the unity. It shows that these genotypes would perform better in poor environments hence these can be utilized as donor parent to breed a suitable lines for poor environments.

Table-38 : Genotypes stable for starch percentage with high and medium mean performance showing stability for other characters in barley.

S. No.	Genotypes	Starch percentage Population mean	Category	Stable characters
1	PL-781	59.21	H	Days to flowering, plant height, days to maturity, 1000-grain weight and biological yield per plant
2	K-1155	60.31	H	Days to flowering, number of seeds per spike and biological yield per plant
3	K-633	58.90	H	Days to flowering, plant height and number of tillers per plant
4	K-794	59.37	H	Plant height, number of tillers per plant, number of spikelets per ear, grain yield per plant, biological yield per plant and malt percentage
5	K-169	58.51	M	Days to flowering, number of tillers per plant, ear length, number of spikelets per ear, number of seeds per spike, grain yield per plant, 1000-grain weight, biological yiled per plant and harvest index
6	Lakhan	58.50	M	Days to flowering, plant height, ear length and 1000-grain weight
7	K-791	57.58	M	Plant height, 1000-grain weight and biological yield per plant
8	K-318	58.07	M	Plant height, number of tillers per plant and 1000-grain weight
9	Amber	57.62	M	Days to flowering, days to maturity, number of tillers per plant, ear length, number of seeds per plant, 1000-grain weight and malt percentage
10	K-141	58.31	M	Plant height, number of spikelets per ear, number of seeds per spike and biological yield per plant
Population mean		**58.69**		

Chapter-VI

Summary and Conclusion

Chapter-6 SUMMARY

The present investigation entitled **"A study on stability for yield and yield contributing characters in barley (*Hordeum Vulgare* L.)"** was under taken with a view to work out variability, heritability, genetic advance, character association, path analysis and phenotypic stability among the 40 genotypes of barley grown over ~~four~~ four environments at the research farm Atarra post graduate college, Atarra, Banda (U.P.) and four environments at Brahmanad Mahavidhalaya, Rath, Hamirpur (U.P.) during 2006-07. The experiments were conducted in randomized block design consisting of three replications with two row of two meter for each genotype in each environment. Row to row distance was kept 30cm and plant to plant spacing 10cm. Experiments were conducted with two levels of nitrogen (N) and two levels of sowing date at two locations over one year. The seeds of 40 genotypes were obtained from C.S. Azad University of Agriculture and Technology, Kanpur. Normal cultural practices were followed in all the experiments to raise better crop.

The observations were recorded on three randomly picked plants of 40 genotypes on the 13 morphological characters (Eleven quantitative and two ~~qualitative~~ quality). The quantitative characters studied were days to flowering, days to maturity, plant height, number of tillers per plant, ear length, number of spikelets per ear, number of seeds per spike, grain yield per plant, 1000-grain weight, biological yield per plant and harvest index and ~~qualitative~~ quality characters ~~i.e.~~ are, malt and starch percentage. The data obtained from experiments at different growth stages and finally

at harvest were subjected to the statistical analysis following the suitable procedure to workout the following objectives :-

I. To find out the variability, heritability and genetic advance for the characters under study.

II. To estimate the character association between yield and its component characters through correlation and path analysis.

III. To find out the phenotypic stability for the characters under study under different environments.

The salient features of the present investigation are summarized here under, environment wise. Experimental data were subjected to analysis of variance, heritability genetic advance, character association, path coefficient analysis and phenotypic stability.

1. The analysis of variance, environment wise as well as pooled analysis showed that mean square due to treatments were significant for all the traits except ear length.

2. Number of tillers per plant, number of spikelets per ear, number of seeds per spike, grain yield per plant, biological yield per plant. 1000-grain weight and harvest index exhibited maximum amount of phenotypic and genetic variability, therefore these characters may offer considerable scope for improvement in the present material.

3. Malt and starch percentage and days to maturity exhibited low phenotypic and genotypic variability suggesting that more

variability is required to be generated for these characters, through hybridization or mutation breeding.

4. The number of tillers per plant, harvest index, grain yield per plant, 1000-grain weight, number of spikelets per ear, number of seeds per spike, biological yield per plant, malt and starch percentage had high heritability therefore simple selection procedure for these traits will be effective. However, only one trait namely days to maturity showed low heritability.

5. On the basis of pooled analysis the maximum genetic advance was observed for number of seeds per spike, number of spikelets per ear and harvest index.

6. High heritability coupled with high genetic advance over mean was observed for number of tillers per plant, biological yield per plant, harvest index, 1000-grain weight, grain yield per plant, number of seeds per spike and number of spikelets per ear indicated that the additive gene effects are of probable importance and improvement in these traits may be achieved through selection. While plant height, ear length, days to flowering, malt and starch percentage exhibited low genetic advance indicating the presence of non-additive gene effects therefore, heterosis breeding programme may be useful for these characters.

7. The success of plant breeding programme depends on the association of various yield component characters with grain yield and quality character. In present study, the characters biological

yield per plant, harvest index, number of spikelets per ear and number of tillers per plant, ear length, number of seeds per spike and 1000-grain weight exhibited positive and highly significant correlation with grain yield ~~per plant~~ and therefore; a population improvement programme should be based on these characters using simple selection procedure.

8. On the basis of pooled analysis it was observed that the character days to flowering showed positive and significant correlation with ear length and number of seeds per spike; days to maturity significantly and positively correlated with number of spikelets per ear; plant height with ear length; number of tillers per plant with grain yield and biological yield per plant; number of spikelets per ear exhibited significant positive correlation with number of seeds per spike, biological yield per plant and grain yield per plant; number of seeds per spike with grain yield per plant and biological yield per plant; biological yield per plant showed positive and significant correlation with tiller number per plant, number of spikelets per ear, number of seeds per spike and grain yield per plant and harvest index showed positive significant association with malt percentage.

9. Biological yield per plant and harvest index ~~exhibiting~~ exhibited positive and significant correlation with grain yield ~~per plant~~ and also had high positive direct effects on grain yield ~~per plant~~, which ~~reveals~~ revealed the true relationship ~~between~~ among yield and ~~both characters~~ biological yield and HI. ^ therefore, direct selection for these traits will be rewarding for yield improvement.

10. The number of spikelets per ear and number of seeds per spike also contributed indirectly towards grain yield through biological yield per plant.

11. The characters number of tillers per plant, number of spikelets per ear and number of seeds per spike had low direct effect but contributed towards grain yield ~~per plant~~ via biological yield per plant.

12. Thousand grain weigh showed low direct effect on grain yield, but contributed towards grain yield per plant via days to maturity, number of tillers per plant, number of spikelets per ear, number of seeds per spike and biological yield per plant.

13. Out of 40 genotypes, seven genotypes were identified as desirable and stable for grain yield per plant in barley, ~~i.e.~~ They are K-273, K-169, K-252, K-792, K-784, RD-2035 and K-794 ~~because~~ as these varieties were having high mean performance, unity regression coefficient and non significant deviation from regression, Therefore, these genotypes can be recommended for commercial cultivation under varied environmental conditions.

14. The genotype K-678, BH-851, K-341, K-791, K-675 and K-804 were high yielding and stable but their corresponding,"bi" values were significantly lower than unity. These genotypes would perform better in poor environmental conditions hence these genotypes can be utilized as donor parent to breed a suitable line for poor environments.

15. Similarly the genotypes Lakhan, Vijaya, Jyoti, K-551, K-790. Lakhan. K-804 and K-141 were observed to be high yielding and stable but its corresponding "bi" values was greater than unity. These genotypes would perform better in favourable conditions and hence, could be recommended for cultivation under better management practices.

16. All the seven stable genotypes for grain yield with high mean performance showed stability for different characters ~~mentioned against each in table-36.~~ Some other genotypes were also identified with medium mean performance and stable for grain yield showing stability with other characters ~~mentioned against each genotype in aforesaid table~~.

17. Considering high mean (>80.02), regression coefficient close to unity (b=1) and deviation from regression zero ($S^2di=0$), the seven promising genotypes namely RD-2684, Manjula, K-678, BH-851, K-792, K-790 and K-794 were detected as desirable and stable for malt percentage over eight environments. These varieties could be recommended for commercial cultivation for malt percentage in environments tested in the present study.

18. While, the genotypes Jagrati, PL-781, K-370. K-729, BEU-73 and K-675 were observed high yielding for malt and stable but their corresponding "bi" values were significantly greater than unity. It shows that these genotypes would perform better in favourable environments and hence could be recommended for general cultivation.

19. Seven stable genotypes for malt percentage with high mean performance (>80.02) had stability with different other characters mentioned against each genotypes in Table-37. Some more genotypes were also identified with medium mean performance and stable for malt percentage showing stability with other characters in the same table.

20. Considering stability criteria, for starch percentage under eight environments only four genotypes were identified as desirable and stable *i.e.,* PL-781, K-1155, K-633 and K-794. Therefore these genotypes could be recommended for general cultivation.

21. However, the genotypes RD-2684, K-729, BEU-73, K-792, K-784, K-1149 and K-804 had high starch percentage and stable but their "bi" values were found significantly lower than unity. Therefore, these genotypes would perform better in poor environments hence can be involved as a parent in the breeding programme of abridging to breed a suitable line for poor environment.

22. Genotypes K-169, Lakhan, K-791, K-318, Amber and K-141 showing stability for starch percentage and medium mean performance also showed stability with other character mentioned against each genotype in Table-37.

Chapter-VII

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Chapter-7 REFERENCES

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